Selection & Use of Materials, Components & Finishes in Engineering Design

Engineering Materials and Design

THE UNIVERSITY OF MICHIGAN

JUNE 19
TWO SHILLINGS AND SIXPENCE
LONDON PUBLICATIONS

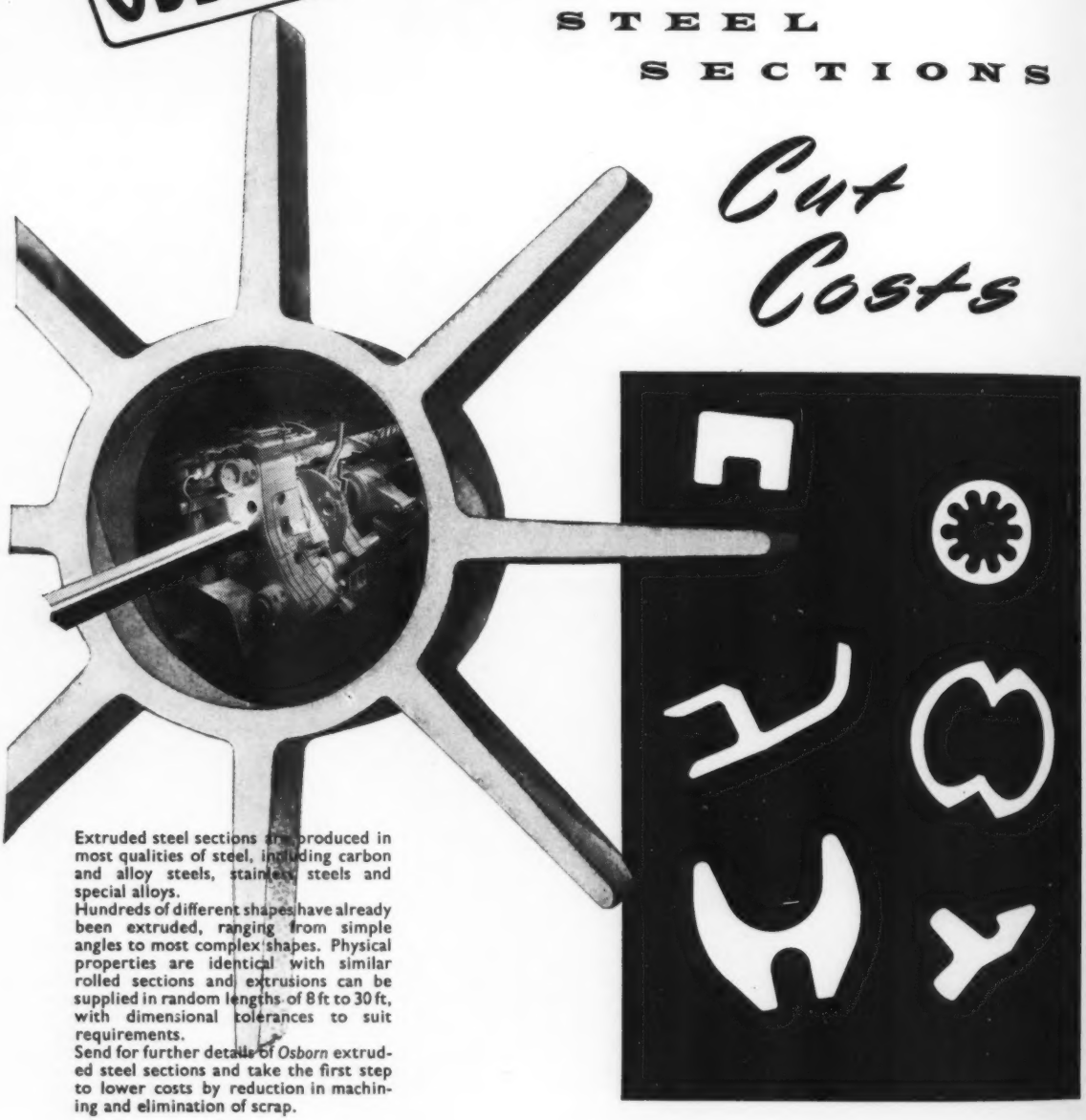
Freewheeling Devices
Page 354

EMD 6533 for further information

OSBORN

EXTRUDED STEEL SECTIONS

Cut Costs



Extruded steel sections are produced in most qualities of steel, including carbon and alloy steels, stainless steels and special alloys.

Hundreds of different shapes have already been extruded, ranging from simple angles to most complex shapes. Physical properties are identical with similar rolled sections and extrusions can be supplied in random lengths of 8 ft to 30 ft, with dimensional tolerances to suit requirements.

Send for further details of *Osborn* extruded steel sections and take the first step to lower costs by reduction in machining and elimination of scrap.

Steelmakers · Steelfounders · Engineers · Toolmakers

Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

Vol. 4 No. 6 June 1961

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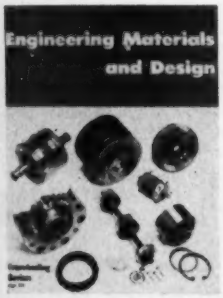

COVER: Some examples of the sprag clutches and other free-wheeling devices which are described in this and the July issue.

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ISSUE AT A GLANCE

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RESEARCH INTO DESIGN ACTIVITY **342**
Describing research carried out by the University of Cambridge with a view to guiding technical education.
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THE GYROSCOPE AND ITS USES **347**
By **J. Tindale**

FREEWHEELING DEVICES—PART 1 ... ... **354**
Survey of the ranges available from the principal British manufacturers and suppliers.

GLASS IN MODERN ENGINEERING **366**
Showing how glass has become an indispensable factor in industry.
By the late **G. W. McArd**

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CLASSIFIED ADVERTISEMENTS ... ... facing page **338**

Résumés

LE VERRE DANS L'INDUSTRIE ET LA TECHNIQUE MODERNES

par George W. McArd page 366

Cette article montre comment le verre est devenu un facteur indispensable de l'industrie et de la technique modernes. Il traite, en particulier, du verre « flottant », du verre mousse et du verre fritté.

DISPOSITIFS DE ROUE LIBRE

page 354

Cette étude souligne les principes des rochets silencieux, des roues libres, des embrayages à cales. Elle donne la gamme que l'on peut obtenir des sept principaux fabricants et fournisseurs en Grande-Bretagne et présente des illustrations.

RECHERCHE SUR LES MÉTHODES D'ÉTUDE

par P. F. Booker page 342

Le Département de Mécanique de l'Université de Cambridge étudie, depuis plus de trois ans, les méthodes d'étude et de dessin afin d'élaborer un guide à l'enseignement dans ce domaine. L'article résume les raisons de ces travaux de recherche et une partie des résultats publiés.

LE GYROSCOPE ET SES APPLICATIONS

par J. Tindale page 347

L'auteur commence avec une description du gyroscope et de ses propriétés. Il traite ensuite de ses diverses applications, par exemple dans la navigation, la construction d'instruments pour la mesure des ondulations sur les routes et les chemins de fer et l'étude du comportement des suspensions de voitures.

Kurzreferate

GLAS IM MODERNEN INGENIEURWESEN

von George W. McArd Seite 366

Der Artikel bespricht die Wichtigkeit von Glas im modernen Ingenieurwesen mit besonderem Hinblick auf die neuesten Entwicklungen mit „Float" Glas, Schaumglas und Sinterglas.

FREILAUFEINRICHTUNGEN

Seite 354

Die Übersicht bespricht die Grundzüge von geräuschlosen Sperren, Freiläufen, Rückanschlägen und Hemmkeilkupplungen. Die von jedem der sieben Hauptfabrikanten und- Lieferanten in Grossbritannien erhältlichen Teile werden beschrieben und illustriert.

KONSTRUKTIONSFORSCHUNG

von P. J. Booker Seite 342

Die Maschinenbauabteilung der Universität in Cambridge hat während der letzten Jahre Forschungen im Gebiet des Ingenieurwesens durchgeführt, die zur besseren Leitung der Nachwuchsschulung dienen sollen. Der Verfasser bespricht den Hintergrund dieser Forschungsarbeiten und einige veröffentlichte Ergebnisse.

DER KREISEL UND SEIN EINSATZ

von J. Tindale Seite 347

Der Verfasser beginnt mit der Beschreibung des Kreisels und seiner Eigenschaften. Es folgt die Besprechung verschiedener Einsätze, z.B. in Navigation, in Einrichtungen zur Messung der Welligkeit von Strassen und Bahnen, und zur Messung des Verhaltens von Aufhängevorrichtungen für Kraftwagen.

Резюме

СТЕКЛО В СОВРЕМЕННОМ МАШИНОСТРОЕНИИ

тов. Джордж В. МакАрд стр. 366

В этой статье указывается как стекло стало незаменимым фактором современного машиностроения. Особое внимание уделяется новейшим развитиям в области пловучего стекла, пенистого стекла и испеченного стекла.

МЕХАНИЗМЫ СВОБОДНОГО ХОДА

стр. 354

Этот обзор излагает принципы безшумных рачек, свободного хода, остановок задним ходом и распорочного конуса. Описываются и иллюстрируются ассортименты компонентов, выпускаемых каждым из семи главных фабрикантов и поставщиков в этой области в Соединенном Королевстве.

ИССЛЕДОВАНИЕ ТЕХНОЛОГИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ

П. Ж. Букер стр. 342

Машиностроительный факультет Кэмбриджекого Университета проводит за последние три года исследовательскую работу в области технологии машиностроения, с тем, что-бы направить в правильное русло технологическое обучение. Статья дает общий обзор этой научно-исследовательской работы и некоторые опубликованные результаты.

ГИРОСКОП И ЕГО ПРИМЕНЕНИЯ

Ж. Тиндейль стр. 347

Автор начинает с описания гироскопа и его свойств. Затем он обсуждает различные применения гироскопа, в частности, в навигации, в оборудовании для измерения волнообразных неровностей шоссейных и железных дорог и в проверке функционирования подвесок гондолы.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Explosion Forming by Electricity

FORMING OF SHEET METAL BLANKS by explosives has been under investigation for some years, particularly in the U.S.A. Although this method has not reached a stage where it can be used on a large scale for non-military applications, there is every sign that it may be used more in the future for on-site forming, now that work-pieces are being required in sizes which are near the limit of transport facilities.

Electrical explosions are now being used by the International General Electric Co., of the U.S.A., in a project to develop low-cost shaping of materials which are difficult to form, e.g. titanium, stainless steel and tungsten. Electrospark forming eliminates the storage and handling problems associated with chemical explosives, and makes isolation of the process unnecessary.

The new process is called "capacitor discharge electrospark forming", and the explosions are induced entirely through a build-up of electrical energy at 35,000 volts and even higher. The forming is carried out under water, which is used as a medium for shock transmission. The electrical blasts create shock waves which are directed against the metal pieces being shaped. Upon impact the metal instantly takes the shape and surface texture of the die into which it is blown, the die having been evacuated to remove air pockets which could cause irregularities. Forming is done at room temperature, and no preheating of the metal is required to make it ductile.

So far the experiments have included the successful forming of pieces 10 in. dia. and $\frac{3}{8}$ in. thick, but further work is planned up to 10 ft. dia. slabs, 1 in. thick.

Cheap Stainless Pipes

A NEW PROCESS for the manufacture of stainless steel and nickel alloy pipe, which will so cheapen the cost of flow line systems that the manufacturers claim they will be competitive with mild steel installations, has been adopted by Welding Technical Services Ltd., of Birmingham. This technique produces helically welded pipe from strip in bore sizes from 3-12 in., with wall thicknesses from 8-20 s.w.g. Welding is continuous and automatic, and is carried out under accurately controlled conditions with the following resultant advantages: (1) pipe of any length may be produced; (2) crevice-free seams provide a clinically clean interior; and (3) wall strength is considerably enhanced by the spiral weld, so that lighter gauge materials may be safely used.

Allied to the existing Weltexa system, by the same makers, which supplies complete pipeline installations ready for assembly by unskilled labour, the new pipe will increase still further its flexibility. The low cost of production will extend the range of stainless steel flow line systems, with the added assurance to users that standard parts are stocked which will allow their line to "grow" as their requirements increase.

Hydrostatic Transmission

THE ADVANTAGES of using hydrostatic power transmission for machine-tool drives were demonstrated with a vertical boring mill by the Department of Scientific and Industrial Research, at the recent Engineering, Marine, Welding and Nuclear Energy Exhibition. Most of the mechanical transmission has been replaced by hydrostatic units. The internal gear under the face plate is driven by two hydrostatic motors, and this gear drives a pump which feeds a small hydrostatic motor on the tool feed mechanism, in order to link the feed with the rotation of the table. Constant cutting speed is obtained as the working diameter changes.

The main advantages of hydrostatic transmission, as applied to machine tools, are constant cutting rate, no gear changing, better surface finish and the elimination of expensive electric servomechanisms. In addition, pump and motor can be positioned conveniently by the machine-tool designer, since they are connected by flexible piping.

The transmission has been developed by Mr. Donald Firth, of the National Engineering Laboratory, who recently won the Wolfe Award for his outstanding work on hydrostatic transmission. Both pump and motor are of the same design, being of the radial-cylinder type, with balls used as plungers. The manufacture of these units has been licensed to Armstrong Whitworth (Metal Industries) Ltd.

A steplessly variable hydrostatic unit of the axial-cylinder swash-plate type has also been developed at the N.E.L. It will run either as a pump or motor, is of high efficiency, and is claimed to be exceedingly quiet in operation. Several British firms have been licensed to manufacture these units.

Rebound Hose

A WATER SUCTION HOSE designed for use where hose is subjected to damage from lorry movements is being marketed by Goodyear, of the U.S.A. Designated the Rebound because it springs back to its original shape after being completely crushed, the hose is being produced in lengths up to 25 ft, and in $1\frac{1}{2}$ and 2 in. diameters.

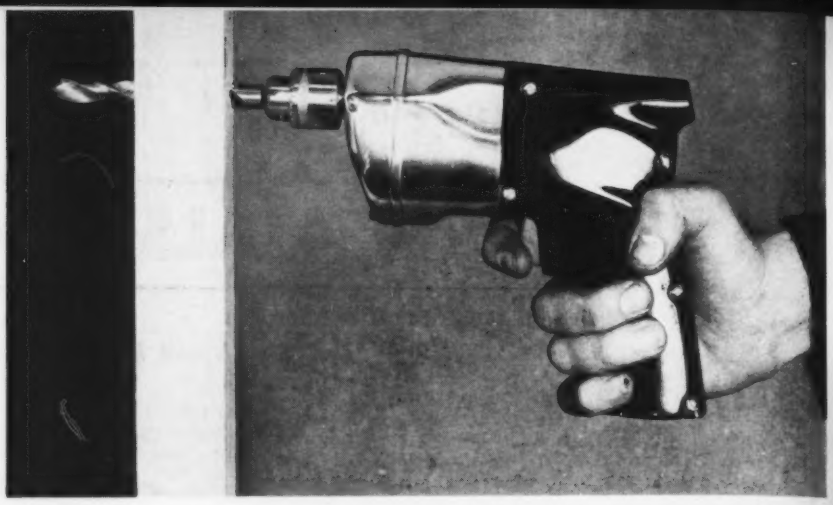
The shape of the hose is maintained by a specially treated rope helix embedded in heavy rubber between the two piles of fabric reinforcement. This helix also prevents the collapse of the hose at high vacuum. The interior tube of the hose is of a non-porous rubber compound that resists the action of sand and grit, and which is also impervious to mildly acid or alkaline water. Although stocked with straight ends only, it can be furnished with enlarged ends if required.

The hose is at present not marketed in the U.K., but may be available here in the near future.

A driver checks a length of Rebound hose crushed under the wheels of his truck, and finds it undamaged.

BATTERY-POWERED DRILL

This portable electric power tool, developed by Black & Decker, is independent of mains power supply. It has a self-contained rechargeable alkaline battery weighing only 4 lb., and is said to be capable of drilling 4-in. dia. holes in steel.

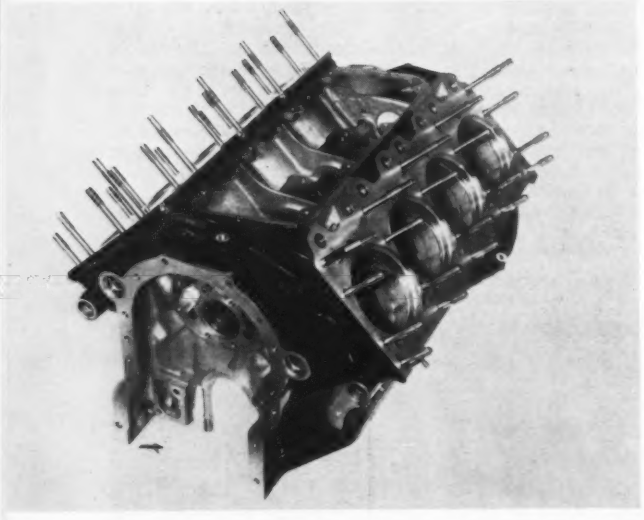


PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

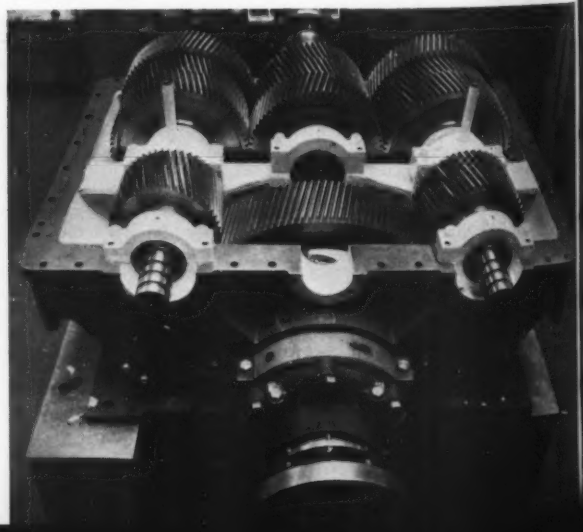
COLD BENDING CRANKSHAFTS

The Pines model 2 bending machine is shown on the right being used to cold form multi-throw crankshafts. A production increase of over 600 per cent. and a cost reduction of more than half is claimed, compared to hot forging (Wickman Ltd.).



V8 LIGHT ALLOY BLOCK

Rolls-Royce Ltd. are now producing a combined aluminium crankcase and cylinder block in LM8-WP for their V8 engine, used in all the Rolls-Royce and Bentley cars. The use of aluminium has enabled the designers to keep the overall engine weight down to that of the smaller six-cylinder unit which it replaces.



TWO-SPEED MARINE GEARBOX

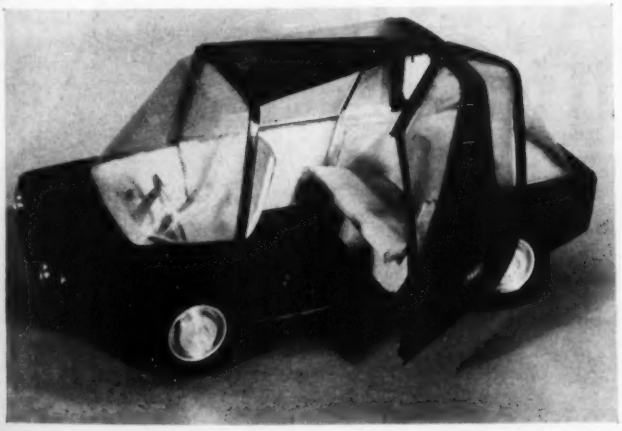
The first two-speed oil-operated reverse-reduction gearbox to be shown running at an exhibition in Britain was the Hindmarch/MWD, shown on right. It was recently displayed at Olympia by Modern Wheel Drives Ltd., and will later be installed in a trawler.

CROSS-COUNTRY CONVEYOR

One of the longest conveyor belts in the world—over 2000 ft. in length—relies on Terylene for its strength. Made by Barrow, Hepburn & Gale Ltd., it can carry 200 tons of sand and gravel per hour (I.C.I. photograph).

HEAVY GAUGE SPINNINGS

Semi-automatic spinning lathes installed by Metal Spinners (Newcastle) Ltd. have enabled the diameter and thickness of spun components to be greatly increased. The range of spinnings now being produced extends from 5-ft. dia. tank and boiler ends in ¼-in. steel, to 3-in. dia. cups in 16 gauge aluminium.



ELECTRIC TAXI

A student at the Royal College of Art, Mr. P. F. Ralph, was responsible for the design of this model of a two-seater taxi powered by a fuel cell. The doors, which hinge backwards, are remotely operated by the driver, and a luggage space is provided alongside him. (C.O.I.D. photograph).

DESIGN AWARD

This Redfyre Centramatic 35 oil-fired boiler was one of thirteen products which received the Design Centre Award for 1961. The instrument-like precision in the design of the front panel is realised successfully in anodised aluminium (C.O.I.D. photograph).

IF YOU USE
POWER
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FERODO
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Consistent transmission of power
Safe, dependable braking and control
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FERODO
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Russian Translations

AS PART of its service to the foundry industry, the British Cast Iron Research Association has undertaken the publication of a complete cover-to-cover translation of the monthly Russian foundry journal *Liteinoe Proizvodstvo*. This will appear under the title "Russian Castings Production", and will form part of the programme of Russian translations sponsored by the Department of Scientific and Industrial Research.

All aspects of castings production are covered in the Russian journal, from raw materials through melting processes and equipment, moulding sands and methods, casting and fettling, to the service behaviour of the finished product. Although the emphasis is placed on cast iron—grey, white, malleable, nodular and alloy—and steel castings, there are also articles dealing with non-ferrous and, particularly, light alloy castings.

Information on how to obtain the results of research and development in the U.S.S.R. and other Soviet orbit countries, in the fields of science, technology and medicine, is also available from the Pergamon Institute, at Oxford. This Institute was formed in 1957 to fill the urgent need for a service which would make available the latest information on significant results of research and development in the U.S.S.R. and Eastern Europe. Today this need is, if anything, even more apparent, since the interest of scientists and technicians the world over in Soviet developments continues to grow far more rapidly than does the number of scientists who know Russian. It is one of the primary intentions of the Institute to fill this need quickly by the initiation of large-scale translation programmes of complete journals and books, as well as of individual papers.

Fibre Reinforced Lead

THE OBJECT of a recent research programme by the Armour Research Foundation, in the U.S.A., was to develop self-supporting lead composite materials by reinforcement of lead structures with metallic fibre mats.

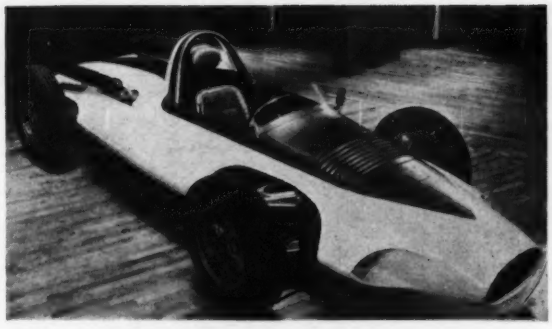
In the first part of the programme the wetting of lead and its alloys on several potential reinforcing fibre materials was investigated, followed by a screening test to evaluate the bonding between various lead alloys and other materials. In this test, the wettability of a droplet of molten lead on a button of the alloy under consideration is determined by measuring the angle formed between the liquid surface and the solid surface. Small angles indicate, of course, that the wetting is good. The wetting experiments are conducted at various temperatures, and in a −40 deg. C. dew point dry hydrogen atmosphere. Contact angles of less than 60° are considered adequate for good infiltration.

In the tests of lead on iron alloys, the wetting angles obtained between chemical-purity lead and various steel substrates ranged from 90-60°. It was evident that additions of copper, nickel and manganese to iron resulted in an improvement of 30° at most in the wetting angle. Carbon, chromium and silicon did not improve the wetting. Commercial ferrous alloys showed similar effects from alloying additions. In all cases the oxide film on the metal surface had to be removed before wetting could occur.

The wetting of copper-base alloys, by chemical-purity lead in general, is poor at temperatures below 482 deg. C., but steadily improves with increasing temperature, so that at 760 deg. C. the wetting is excellent. Copper-base fibre metal structures should be readily wet and infiltrated with lead at 760 deg. C. or higher. Nonferrous alloys with stable oxide films, such as aluminium and beryllium copper, are not wet at any temperature. The experimental data, in general, are in agreement with the predictions based on interfacial tension considerations.

Research Vehicle

THE CERV-I (Chevrolet Engineering Research Vehicle) has been developed as a research tool for investigations into automotive ride and handling phenomena. In order to amplify vehicle responses to handling and road stimuli, the performance capability of the vehicle must be extended far beyond that of regular passenger cars. In other words, a high power-to-weight ratio is mandatory. By such means, suspension phenomena that are extremely subtle, and thus difficult to isolate within the performance capabilities of a regular passenger car, may



Showing the aerodynamically styled CERV-I

be studied and treated quantitively.

Another fundamental factor in this experimental car's design is the visibility afforded by the body design. The streamlined abbreviated body encloses the engine, transaxle, and engine cooling system, and provides an open cockpit for the driver from which all four wheels in contact with the ground are clearly visible. Special design features are: extremely light weight, to give a horsepower-to-weight ratio similar to that usually associated with high performance aircraft; rear mounted engine in unit with a fully synchronised four-speed transaxle; and all four wheels independently suspended to provide a high order of stability and positive handling.

The car weighs approximately 1600 lb. ready to run, the extremely stiff frame of chrome-molybdenum steel tubes welded into a truss-like structure accounting for only 125 lb. The body is fabricated from a glass fibre reinforced plastics somewhat thinner than that used in the Corvette body. Power is supplied by a specially developed lightweight version of the Chevrolet 283 cu. in. V-8, which develops 350 h.p. and weighs only 350 lb. Such specific output, only 1 lb. per horsepower, is rarely achieved in reciprocating engines, even in the most highly developed aircraft types.

The considerable reduction of weight was achieved by using aluminum for the cylinder block, cylinder heads, water pump, starter motor body, flywheel and clutch pressure plate. No bore liners are used in the cylinder block, and the pistons run directly on specially treated aluminum bores. Magnesium is used for the clutch housing, fuel injection manifold and manifold adaptor plate. Weight saving achieved through the use of lighter metals in the engine and clutch is more than 175 lb. The engine cooling system consists of an aluminium radiator mounted forward of the driver, and two oil cooler radiators mounted one on each side of the main radiator.

So that weight distribution during tests shall vary little if any, two fuel tanks of rubber construction and total capacity of 20 gallons are located on either side of the CERV-I at approximately the fore and aft location of the centre of gravity.

The chrome-molybdenum steel tubular frame of the CERV-I weighs only 125 lb.

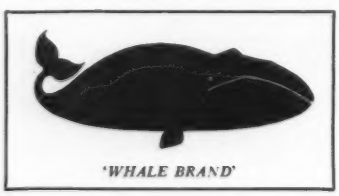
Why T. S. HALL rely on TUFNOL for cams and form blocks

T. S. Hall Limited, of Bristol, main suppliers of grill pans to gas and electric cooker manufacturers, now use 'Whale' Brand Tufnol exclusively for their cams and form blocks.

In this application 'Whale' Brand Tufnol has many advantages over steel. It is one-sixth the weight, making it easier to handle; it can be machined in one-fifth of the time; and it costs far less than steel or any of the special alloys that have been used.

The 'Whale' Brand Tufnol form block in the main illustration has produced over one million grill pans —and it is still in excellent condition!

There are eleven other brands of Tufnol, available in sheets, tubes, rods, angles and channels. All brands are laminated plastics; each formulated to satisfy specific requirements. Your local Tufnol Branch Office will gladly provide you with further information.



'WHALE BRAND'

TUFNOL

(REGD. TRADE MARK)

TUFNOL LIMITED, PERRY BARR, BIRMINGHAM 22B

395

Layer Insulation for Low Temperatures

THE STORAGE AND TRANSPORT of large quantities of cryogenic fluids is rapidly becoming an important activity. Techniques for insulating the associated equipment are progressing rapidly, and an interesting article in the March 1961 issue of *Cryogenics* describes the development of multi-layer insulation, which gives a lower rate of heat transfer than any other type of insulation. Best results have been obtained with aluminium foil separated by layers of glass fibre paper. However, many other combinations of reflector and insulating materials may be used.

The cost of this insulation is relatively high, both in material and man-hours for its application, but justification for its use must be worked out in terms of its ultimate saving of cryogenic fluid or insulation weight. For instance, its use make possible the storage of liquid helium without the necessity for a liquid nitrogen shield. It can also be used for the insulation of large liquid transfer lines. Other uses include applications in the missile and space exploration field, where its good insulating properties and low density make it especially suitable. Future requirements of the space age may well rely heavily on this type of material.

Tantalum for High Temperatures

WITH ITS HIGH MELTING POINT (2996 deg. C.) and retention of plasticity down to −196 deg. C., tantalum offers the greatest temperature range of structural usefulness of any metal. Though already in general use in various electronic applications, the metal's most immediate potentialities appear to lie in the use of its alloys in high-temperature environments. As a material of construction, tantalum's future seems to lie in the temperature region just below that served by tungsten, and above that served by the lower melting alloys of molybdenum and columbium.

According to D. J. Maykuth, metallurgist at Battelle Memorial Institute, tantalum shows extensive solubility for many high-temperature strengtheners, including tungsten, columbium, molybdenum, vanadium, hafnium and zirconium. Moreover, it has good tolerance for impurities such as carbon and oxygen. These facts make tantalum alloys less susceptible to contamination in processing than some other metals. The metal's disadvantages are its high density, costliness and limited oxidation resistance at high temperatures. Tantalum alloys require protective coatings in oxidising environments.

Several tantalum-base alloys with excellent high-temperature potentialities have been developed. Thus, a tantalum-base, 30 columbium, 5 per cent vanadium alloy is especially attractive because of its low density as compared with tantalum. At temperatures from 1200 to about 1400 deg. C. tantalum alloys are expected to have strength-to-weight ratios at least as great as columbium alloys, and they should have greater strengths at higher temperatures. Indeed, because of the metal's high melting point, tantalum alloys may find use in the 1400 to 2200 deg. C. range, where only tungsten now serves as a metallic material of construction.

THE JULY ISSUE

of *Engineering Materials and Design* will include the following main features:

Glass—Its Role in Powder Metallurgy

Dealing with various applications of sintering under glass.

Freewheeling Devices—Part 2

Concluding section of the survey of silent ratchets, free wheels, backstops and sprag clutches.

Progress with Refractory Fibres

Discussion of some of the high-temperature insulating materials based on refractory fibres.

Standard Nuts for Bolts and Screws up to 1.0 in. diameter.

Illustrating the hand mixing of a small quantity of Armstrong Expandofoam—(*upper left*) combining a polyether based prepolymer with an activator and inflating agent; (*upper right*) the liquids being mixed by hand; (*lower left*) the mixture being poured into a larger container for foaming; and (*lower right*) the mixture at the completion of the foaming cycle, as it begins to solidify

New Urethane Insulation

A NEWLY DEVELOPED TYPE of foamed-in-place urethane insulation is being marketed by the Armstrong Cork Co., of Lancaster, Pennsylvania, U.S.A. It consists of the reaction product of a liquid prepolymer combined with a liquid activator and inflating agent to produce a solid insulation of minimum density with exceptionally good structural strength and thermal efficiency. The prepolymer is toluene diisocyanate partially reacted with a resin. The activator contains additional resin in sufficient quantity to complete the chemical reaction when mixed with the prepolymer; it also contains a surfactant to control cell size of the foam, a catalyst, and the inflating agent which vaporises from the heat developed during the chemical reaction and forms the cell structure of the foam.

Called Expandofoam, it is composed of uniform, small closed cells, and has unusual toughness and strength. By different formulations and engineering, various conductivities, densities, use temperatures and degrees of rigidity and toughness can be obtained. It is possible to develop systems with fast or slow foaming rates, self-extinguishing properties, or other qualities to meet the insulation and design requirements of a wide variety of types of refrigerated equipment.

The high thermal efficiency of Expandofoam allows wall thicknesses to be cut almost to half, so that 50 per cent less insulation is required. High strength and toughness allow cabinet structures to be redesigned, incorporating substantial economies by using lighter parts and eliminating framing members. The high moisture and vapour resistance of this new foam eliminates moisture infiltration problems, and the expensive sealing methods often needed to combat them.

All systems can be hand or machine mixed, and free or mould blown. A free-blown application allows the foam to expand freely in at least one direction, while a mould-blown foam's expansion is confined on all sides.

In hand mixing, the activator with inflating agent is combined with the prepolymer, vigorously agitated, and then poured into the space to be filled (see illustration).

Argon shroud being used in aluminium stud welding

Aluminium Stud-welding

A NEW TECHNIQUE has been devised for stud-welding to aluminium alloys which has the effect of minimising porosity and atmospheric contamination. Recent tests, carried out by Crompton Parkinson (Stud Welding) Ltd. on the cast metal produced by an aluminium stud weld, showed that this metal suffers from impurities derived partly from the film of oxide and partly from the residue of a drawing lubricant on the stud, and further aggravated by atmospheric contamination during the weld cycle. The film on the stud was removed by skimming it in a lathe—the contamination was dealt with by excluding the atmosphere and substituting argon gas in its place.

The inert gas is introduced and contained in the weld zone through a brass shroud which goes around the stud and ferrule in the weld position. A valve attachment at the base eliminates gas wastage by releasing the argon flow only when the hand tool is in position. The use of the argon attachment has been proved to be completely successful for the complete range of aluminium alloy studs up to and including $\frac{7}{16}$ in. dia.

On $\frac{1}{2}$ in. studs the complete prevention of porosity set a greater problem, and to overcome the slight reduction in strength caused by microscopic porosity the weld base area was in effect increased. This was done by making use of the metal displaced when the stud is returned to the molten pool. Investigations showed that fusion does not occur between the displaced metal and the stud sides because the stud periphery is too cold. This led to the development of a preheat arc unit, the function of which is to heat the stud to the required temperature immediately before the weld is made. In practice, it is found that a current of approximately 70 amps and a duration of 3 sec. give the desired conditions for a $\frac{1}{4}$ in. alloy stud. With the exception of the argon attachment and the preheat arc unit, the rest of the equipment is completely standard.

Drawing Office Equipment

A FULLY-EQUIPPED modern drawing office, fitted with all the latest equipment, will be a special feature at the first Drawing Office Equipment and Materials Exhibition, to be held this year from June 5-8 at the Royal Horticultural Society's New Hall, London. Suitable items are being chosen from the exhibitors' range of products for inclusion in this model drawing office, which will occupy an area measuring 65 x 36 ft. It will illustrate the technical advances in specialised equipment for the up-to-date drawing office, and show how industry can utilise modern layout as an aid to efficiency.

Entwistle, Thorpe and Co. Ltd. (86-88 Pentonville Road, London, N.1) will demonstrate a German Royal Zenith 29 offset litho machine which prints architect's and engineer's standard drawing sheets. From the U.S.A., they are showing Lietz drafting templates, pressure sensitive drafting aids—transparent and opaque coloured tapes for preparing charts, graphs, maps and layouts—and Pickett slide rules. Their British exhibits include Replimaster transparencies, of special interest to instrumentation and electronic engineers; Statfile recording for reducing large drawings to half plate films; and other processes of interest to architects and engineers. They are also displaying a selection of artists materials.

W. H. Harling Ltd. (117 Moorgate, London, E.C.2) will exhibit all-British products. They are showing a full range of their own stainless drawing instruments, equipment and instrument cases, as well as artists and designers brushes and B.R.L. slide rules; a new triangular ruling pen handle, made of nylon, and said to be unbreakable; instruments with tungsten steel ink points to give long life on abrasive surfaces; and a comprehensive range of Beam compasses.

Esmond Hellerman Ltd. (Hellerman House, Windmill Road, Sunbury-on-Thames, Middlesex), will show a comprehensive range of both their own and overseas drawing equipment, and special lines new to the market, including their Hellerman photoprint machine for use in engineering shops and drawing offices, and for educational purposes. They are also exhibiting the Linex hatching machine, and Rino set squares, which are made of a new material.

Fire Retardant Paints

CONSIDERABLE INTEREST has been shown over the past few years in fire retardant paints of both the solvent and water-based types. National Adhesives Ltd., and their associates in the U.S.A., have devoted laboratory time towards developing such paints—in this case those of the water-based type.

The basic idea was to develop a one-package stable water-based product with excellent fire retardancy, and that such a product should exhibit adequate paint properties as well. For example, easy application, can stability, tintability and a degree of washability should be inherent in the product. In other words a fire retardant *paint* was needed, not just a fire retardant coating.

The result is that an interesting paint has been developed that gives excellent fire retardancy, whilst retaining the other properties of a paint as mentioned above. The fire retardancy is attained by the use of various comparatively water soluble ingredients, including mono ammonium phosphate. These materials, when heated, puff up or intumesce, forming a spongy cell layer. This layer effectively insulates the underlying surface from the impinging flame or heat, thus preventing combustion.

Because of the high amounts of water soluble salts necessarily included in the paint to attain the correct degree of intumescence, any vehicle used must of course be stable in the presence of such salts. Thus the formulation eventually developed necessitated the selection of one particular p.v.a. emulsion.

Paints made to the formulation MB4/4 have been submitted to the BS 476 " spread of flame " test, and have been given a Class A rating on a surface such as combustible fibre board, the rate of application being of the order of 200-275 sq. ft. per gallon of paint.

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THE NON-PROFESSIONALS

MUCH has been written on what constitutes the definition of an engineer, and his status in modern society. In a recent issue of *The Professional Engineer,* Edwin Fleischmann discussed the factors which establish an individual as a professional man. William J. Jaffe dealt with the same problem in an address to delegates at the Summer Annual Meeting of the A.S.M.E. At the same meeting Dr. Robert Yarnall Jnr. presented a paper entitled "Motivating Subordinates to High Performance." While all these have as a theme professionalism, and are worthy of perusal and study, one must not forget the humble and routine jobs which are equally important in successfully running an engineering establishment.

Today, probably more than at any other period in industrial history, the success of a product, whatever its size or cost, whether it be an inter-continental missile or a domestic toaster, depends very largely on team-work. In show business there is a saying; "There are no small parts," meaning that each part, whether it contains one word or one hundred thousand words, demands equal thought, concentration and endeavour to attain the ultimate goal. This is equally true, though rarely appreciated, in engineering. Whatever its status, each section is ultimately dependent on the others. The sales division depend on a good product to substantiate their promotion schemes; the rest of the organization depends on sales for an income. The design office depends on the works to interpret their designs, while equally the works depend on the staff for designs appropriate to their skill and equipment.

Other categories must not be forgotten, for example, the storekeeper is responsible for tools, drawings and material. How often this job is delegated to those who are completely ignorant of organization, and also irresponsible, thereby causing untold delays which result in higher costs and loss of repeat orders, because of failure to keep delivery dates. And what about the chap who sweeps the factory floor, or the "daily" who keeps the offices clean—how often these essential services are overlooked when planning for efficiency. Factory workers cannot work properly in a muddle of offcuts, shavings and dirt, any more than a designer can work surrounded by a pile of crumpled, disregarded drawings and schemes, and with overflowing ashtrays, and pencil shavings littering the floor. Good cleaners are worth considerably more appreciation from workers and management than they usually receive.

There are many other workers who receive little or no recognition of their efforts and services, for instance the factory clerks who schedule materials and parts; the tracers, who often have to interpret appalling figures; and the typists, who are equally beset by appalling writing—it is said that doctors and engineers are the world's worst writers. It is true that no one is indispensable, but a failure of any of the categories mentioned can cause considerable disruption in the otherwise smooth progress from design to production, and may very well lead to a second-rate product, either functionally or aesthetically.

As much as it would be welcome, it is not intended to advocate increased pay for those so often relegated to the background, but rather to draw attention to the fact that this unspectacular work should be more widely appreciated. Mundane repetitive tasks have to be done by someone, and because they are mundane and unspectacular that is no reason why those that do them should receive no credit for their endeavours.

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SUPERSONIC OR SUBURBIA?

THERE is much speculation at the present time on the future operating speed and technical design of commercial airliners. Psychologists have even been discussing the effect on passengers of eliminating windows, so that a stronger fuselage of light weight could be produced to withstand very high speeds and their associated high skin temperatures. It would appear that the purely technical problems of designing faster-than-sound aircraft are nearing solution, but for commercial exploitation it is first necessary to relate speed to the cost of construction and operation.

Dr. A. E. Russell, leader of the British Aircraft Corporation team engaged on a design study of a supersonic airliner project, recently advocated a Mach 2, rather than the Mach 3 airliner that some people have proposed. Dr. Russell pointed out that the aircraft form for Mach 2 can have a narrow delta wing of which the leading-edge sweep allows sufficient thickness and volume to contain the fuel and main landing gear, whereas the shape most generally favoured for Mach 3 appears to be a canard whose delta main wing has moderate sweep and very low thickness, so that a substantial amount of fuel must be stowed in the fuselage, thus reducing the space available for passengers and freight. A further advantage of wing fuel stowage is that, by a simple device, a free exchange of heat from the wing surface to the fuel is prevented, so that the fuel can act as a heat sink for the air-conditioning system. Dr. Russell also had a good deal to say about thermal heating caused by air compression and friction. For Mach 2 aircraft, of which the structure would reach a temperature of 120 deg. C., aluminium alloys could be used, but for Mach 3 the temperature would reach 275 deg. C., and large amounts of stainless steel or titanium would be essential.

All this makes a fascinating story of development, and engineers may argue long into the night on the relative merits of Mach 2 and Mach 3, or on the problems of cooling hydraulic systems on supersonic aircraft. A favourite question to ask is "When will the first supersonic commercial airliner be brought into operation?" Perhaps it would be wiser to ask: "Should the supersonic airliner be permitted?" Lord Brabazon, addressing the Roadfarers at a recent luncheon, went so far as to call the supersonic airliner "anti-social". No one could accuse Lord Brabazon of being unprogressive, but he has pointed out that an airliner flying at Mach 2 would sweep the earth with a shattering thunder path more than fifty miles wide—merely to permit a few business men or film stars to save an hour or two on a journey of a few thousand miles. We agree with him that the tremendous cost of developing supersonic aircraft, military considerations apart, is hardly justified in order to speed up the air travel, compared with the improvements which could be made to road or rail services from the airport terminals, for the same expenditure.

A more sensible development would seem to be the vertical rising aircraft, which may well revolutionise air travel of the future. Many new problems await solution in the commercial development of vertical take-off and landing (v.t.o.l.) aircraft, not only regarding the design of the aircraft itself, but in redesigning the size, shape and utilisation of airports. Surely there is enough scope in pushing on with v.t.o.l. projects to extend to the full the ingenuity of aircraft development engineers. Engineers usually consider themselves dedicated to the practical service of mankind, and public opinion is usually more favourable to engineers than to scientists, whose brilliant achievements are apt to rebound on a helpless public. Obstinate development of supersonic aircraft for commercial purposes may well have an unfortunate effect on public opinion towards engineers at a time when they are struggling to improve their status in society.

The Editor

RESEARCH INTO DESIGN ACTIVITY

Members of the University of Cambridge Engineering Department have, for some years, carried out research in the general engineering field with a view to guiding technical education. During the past three years attention has been turned towards engineering design. The background to this research and some of the published results are reviewed below

by P. J. BOOKER, A.M.I.E.D.

RESEARCH and design are similar in that they are both activities, but beyond this they differ greatly, particularly in their end products. Design starts with abstractions, but works its way along towards reality in the shape of material products; it is creative, or a synthesis. Research starts with reality and works its way backwards towards generalised abstractions which are easier to think about than the real complex world; it is analytical. Persons brought up in the research world rarely have any understanding of design. Equally, designers on the whole do not understand the nature of research. In writing about research to designers, therefore, there is some difficulty, especially as the research with which we are concerned is centred upon design itself.

Why should researchers turn towards studying design? It is true that the results, in the long run, may be helpful to designers and may lead to better or more efficient design, but this is not the motivation. The crux of the matter is really education. Educational patterns change slowly, but they change nevertheless, and over a period of time these changes can be profound, although unrecognised generally. Whereas in most fields of human endeavour new ideas can be put to the test before adoption, this is not so in education. The result of educational changes is not apparent for at least a generation, and it is interesting to consider that what we are today is some function of how our grandfathers thought we should be educated or trained.

Years ago very few persons were able to go to a university. This left a very large pool of people with a high potential, many of whom became engineering apprentices and ultimately designers. The new social pattern aims at creaming off all the intelligent youngsters with a view to giving them a university education. Cutting a long argument short, this is serious, because it means that, unless great changes are made, all future intelligent children will more or less be shaped in the analytical mould rather than the creative mould. This problem is already with us. There are many university-trained men employed in *design teams*, although few of them can be considered *designers*. Recent research suggests that, almost unconsciously, industry has developed patterns of design organisation which allow a large number of persons with limited potential and qualities to work together effectively, supplementing one another. So far this has worked because among these teams are a number of creative types who are really the instigators of all new ideas. What will happen if fewer and fewer of these leaveners are available as time goes by?

There is a distinct possibility of this happening. Recent research in the U.S.A. has shown that the creative types are those who have not been subjected to a way of life or thinking which tends to make persons conform. In a peculiar way, subjecting increasing numbers to university education—as it exists now—*is* a kind of conformity.

Need for Education in Design

Rapid technological progress has not helped much. It has lifted engineering education more and more into the realm of theories and abstractions—to such an extent that some graduates are simply lost when they first encounter industry. Some buckle down to a re-education; others move into research or other "intellectual" activities, continually, in effect, stripping design of the brains it needs.

Some people in most universities are very aware of this situation, and from time to time there are suggestions for injecting some sort of design activity into engineering education. In practice, however, there are difficulties; in particular it is very difficult to define or pin-point its nature

sufficiently to take any realistic action. If one runs through the design of a valve, for instance, students might learn something about valves, but what have they learnt about design? Designers themselves rarely analyse their own work, or their ways of working or thinking, with the result that educationalists can find very little recorded which will help them. The answer then is to find out, and finding out, to scientifically trained men, means objective research.

Research into engineering design is not as tidy as, say, physical research. There is little that can be measured and recorded in terms of figures. The pattern of activity is much the same as that used by all of us in everyday life, except that it is carried out painstakingly and systematically, any conclusions reached being checked as far as possible.

The recent research carried out by members of the Engineering Department of Cambridge University started by going into industry to actually watch design projects in process, and to record everything about them which might be useful. This included investigating the design organisations, the personalities involved and their backgrounds and past histories, how designs were broken down, what functions individuals performed and so on. The mass of evidence obtained was, of course, prolific. On top of this factual evidence, all sorts of other questions presented themselves for examination: What is creativity?—How do people think up solutions to creative problems—What is experience?—and so on.

MACHINE DESIGN

The third science is that of machine design. This has been removed by Redtenbacher from its incorrect position as a part of applied mechanics, and established on a footing of its own. Its province is to show how the parts of the machine are to be proportioned so as to resist deformation. In order to accomplish this fully, they must be considered both with reference to the external forces acting on the machine, and the corresponding molecular forces within its substance.

The former are assumed as determined by theoretical mechanics; these define the requirements of the parts as to strength. The latter, the molecular forces, transmit the force action from part to part, and cause also friction and wear. The science of machine design applies the results of research in these two directions to the special problems with which it deals. When it solves these problems in accordance with technological requirements, it forms a really technical science.

REULEAUX, ***Theoretische Kinematik (c. 1870)***

Design in Terms of Critical Decisions

From all this it seemed necessary in the first place to isolate some "sameness" which could form a basic picture of design against which other complexities could be viewed in proper perspective. Since the products of industry are so varied, a picture in terms of things or design entities—plants, units, assemblies, components, etc.—was of limited value, although still useful; and since design organisations varied from many hundreds down to one man, design in terms of people raised great difficulties. One similarity did, however, show up among all the cases studied. Throughout the design process, *decisions* were being made, and these could be broken down into decisions which were made in order to get information, and those *critical decisions* which affected the designs themselves and which set the pattern for all future design work and subsequent decisions.

Consequently, a new picture—a basic abstract model—of design in terms of critical decisions was created. This was checked against the case studies recorded and, from this, patterns of appropriate behaviour were deduced, these also being checked against examples of such behaviour in the recorded cases. This new picture of design has been published in a paper by D. L. Marples entitled "The Decisions of Engineering Design".* It is impossible to summarise this paper in a few paragraphs, but it will be of interest to get some idea of the picture it paints.

Design is seen as a sequence of critical decisions leading from the statement of the problem to the detailed specification of hardware. While many general decisions may be made in the course of any design, the critical decisions are of a specific nature, each consisting of: (1) a number of proposals for solving a problem; (2) predictions of the outcome of each proposal, with particular emphasis on the sub-problems which each entails; and (3) an evaluation of the outcomes in terms of criteria originating from the natural properties of the material involved, from engineering values, from prior decisions, and from the judged intractability of the unassessed portion of the design.

Drawings, models, calculations and tests are made to relieve the designer of the need to make excessive demands upon his imagination, in order to predict the future behaviour of the hardware with greater certainty, and in order to disclose the sub-problems associated with a given proposal. The examination of proposals may be conducted in parallel or in series. The first method is to be preferred, because it is likely to save time, to give a better insight into the problem, and to avoid personal attachment to a single proposal. If the second method has to be used—and lack of manpower often makes this necessary—it is better to rank the proposals for priority in terms of their expected advantages rather than in terms of how easy they will probably be to examine.

Time an Important Factor

If any one element stands out in these case studies it is *time*, a factor which, although perhaps obvious, is rarely mentioned in the literature of engineering design. Time not only presses incessantly as a whole, but such things as development time, procurement time, etc., are often criteria which discriminate against otherwise perfect solutions. There always has to be a compromise between efficiency in the sense of saving time, and certainty in the sense of fully examining all possible solutions. This balance between efficiency and certainty occurs at different points with different persons, but it seems true to say that the necessity of convincing a number of persons of the correctness of a decision leads to a bias in favour of certainty.

The cases which were examined showed few if any flashes of inspiration. In fact, the pressure of time was invariably such that novelty, if it required development or proving time, was at a discount. Contrary to popular opinion, a designer shows up in these case studies not as a freak bursting with ideas, but as a man who knows innumerable standard ways of doing jobs (experience?) and can use his thinking capacity to rearrange problems and solutions so that they fit these standard ways. Only when no standard ways appear feasible does he seek new ways. Innovation is imposed upon him and not sought by him.

This article, describing design in terms of decisions, will probably be of most interest to managers, educationalists and engineers who have to make high-level decisions, much more so than to the average practising designer. Nevertheless, the article is being made available to designers for a specific purpose. Since research into design takes time and labour, it is costly. There are no readily available funds

* *Copies of this paper are obtainable from The Institution of Engineering Designers, 38 Portland Place, London, W.1.*

for this purpose, so it is impracticable for researchers to go out and examine dozens of different types of design work. Instead, practising designers are asked to examine this abstract model with respect to their own work. From the comments received it will be possible to gauge whether this model is appropriate to a greater or lesser degree to all design work, or only to some kinds of design work. In short, subsequent research will depend very largely upon an analysis of such comments.

Whatever may be the long-term effects, this new picture of design has already proved itself to be useful in one respect. Designers from time to time try to record a design in terms of its evolution over time. The success or otherwise of these attempts depends upon what fundamental framework or picture these designers have in mind. The critical decision picture is such a framework; it immediately puts the evolution of a design into chronological order, since decisions cannot be taken out of order, because each depends upon the previous decision. Focusing attention on to decisions also pin-points the various proposed solutions at any stage of the design from which a selection had to be made, and this in turn means that reasons for the choice follow naturally. One or two small-scale design stories have been built up in retrospect upon this basis, and they have been very illuminating, not least to the designers themselves. It is hoped that the firms concerned will allow the publication of these stories in due course.*

Research is expensive, because the bulk of the effort goes towards collecting evidence. The subsequent analysis is an armchair intellectual exercise often costing nothing. It seems that much could be done by part-timers (possibly designers or college students) collecting data for submission to a common pool. Apart from building up a large number of design case histories covering a wide range of industry, it would be extremely useful to have records of a number of design units detailing the persons employed, their functions, education, ages, kinds of experience and so on. As well as being of real use, the collection and publication of such information would help to give design and the designer much needed publicity.

Limited Value of Abstract Models

While the information gathered to date and the results so far published are useful, they are useful in a limited way, and possibly tend to become more and more of academic interest as one moves along from initial abstractions to concrete hardware. This is particularly so in the mechanical engineering field, to the point where some mechanical designers might well call abstract models of design utter rubbish. There are reasons for this, and an elucidation of them might at least point to other areas for research.

In mechanical design, as opposed to many other forms of design, one is dealing with raw materials most of the time rather than the arrangement of existing or potentially existing parts or equipment. The properties of raw materials and those of the parts made from them have only a remote connection. The properties of any component are predominantly a function of its *shape*, which is not inherent in the material itself. Likewise, the properties of a number of parts or elements suitably arranged into an assembly or mechanism are also different from, and not inherent in, the individual parts. In a way, of course, this is true of all design work, but it is particularly pertinent to the design *of* hardware as opposed to design *with* hardware. The reason is that geometry, i.e. shape, plays so important a part, and the latitude for shape or arrangement is extremely large, if not limitless. This gives so many possibilities that the probability of making errors or missing the optimum shape is proportionately large.

The vast range of shapes and arrangements at our disposal is limited in practice by our experience of how similar parts behaved under similar circumstances—*if we have such experience*. It is useful to note that we mean here not collective experience, but individual experience, and this is probably one basic reason why design work is such a personal thing. In hardware design, geometry is fundamental—the shape of individual parts, the interaction of parts with one another, tolerances, allowances, backlash, distortions and deflections, errors in shape, surface finish, etc., are all manifestations of shape, i.e. geometry. This is why drawing holds such a pre-eminent place in such design—it reflects the design's geometry because it is virtually a copy of that geometry. Calculations and tests, useful and necessary as they are, can only arise *after* some shape or arrangement is postulated.

Summing Up

We may now come back to our original discussion. Up to the present, designers have emerged from engineering apprentices. We recognise that during their periods on the shop floor they learnt much about production processes. Because of this, production methods have been isolated, analysed and taught to persons who are going into industry by other routes. However, workshop experience has provided much more for today's designers. It has given them a feel for materials, for fits, for accuracies, and, more important, it has confronted them over a long period of time with an endless variety of shapes and arrangements which unconsciously they have analysed and stored in their memories. In short, this "exposure" to these things has made these men what they are, and if designers are to emerge through other channels in future, then what is lost by not serving an apprenticeship in the workshops has to be ascertained, analysed and positively imparted in some other way. This is not impossible; indeed, it should be possible to implant very many important concepts more positively and certainly than is possible by simple "exposure".

In consequence, where hardware design is concerned it might be very useful to conduct research in those particular areas which have, in the past, been the training ground for designers, to see what in fact they did learn from practical work, and which is lacking in non-practically trained men. We may think we know—perhaps we do, but it is unproven and there may be other factors we have not yet recognised.

When it comes to basic education for prospective designers, there is no need to be at a loss. Look carefully at the quotation appended, and then remember that this was written nearly a hundred years ago. Successive generations of textbook writers base their work on the books of their immediate predecessors, each cutting out what they think to be obvious or redundant, in order to make room for more material. What they, being mainly educationalists, considered redundant, and what engineers consider redundant are not necessarily the same. Once a generation of writers has dropped something, it is virtually lost until someone thinks of it again, or until some curious person delves back into the past. How many young engineers today are fully conversant with the techniques of scaling up (or down) machines or even parts? Yet the principles were expounded by Galileo, and were discussed quite extensively, and practically, in mid-nineteenth-century textbooks.

Proper research into the technical literature of engineering—especially drawing and design—over, say, the period 1850 to 1910 would bring to light, and allow to be collected together, most of the basic ideas essential to mechanical design, but which today are glossed over or taken for granted in the present race for higher and yet higher technological education.

Research in the field of engineering design is interesting to the point of fascination. It is worth while and covers a large area. Best of all, it is a field in which the individual can still operate effectively.

* *"Designs in the Making—1: a Special Purpose Mechanical Design,"* by *P. J. Booker and J. Prince*, The Engineering Designer, *March, 1961.*

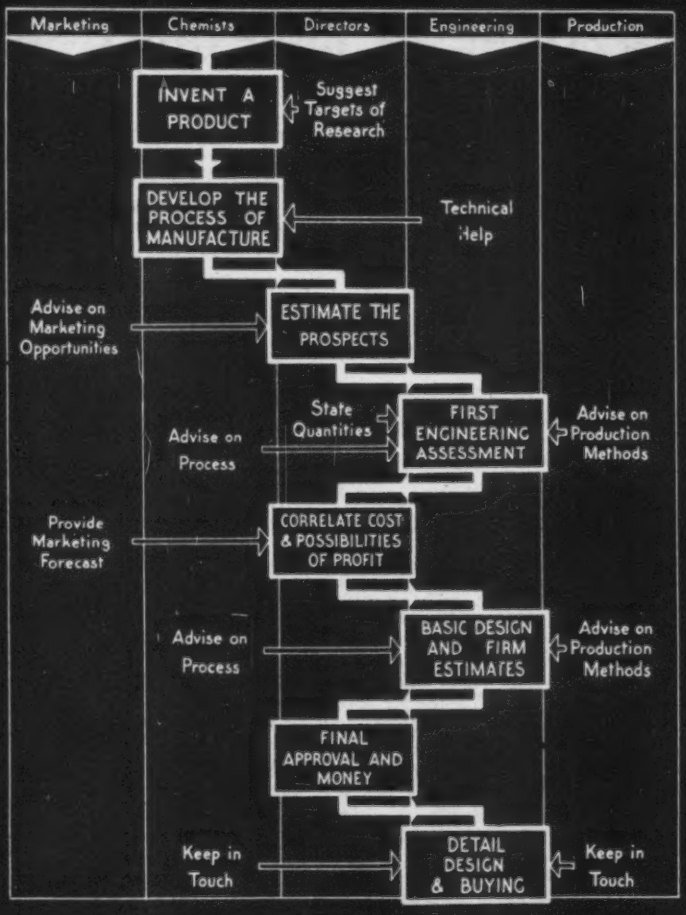
PICTURES OF DESIGN—Design displayed in terms of personnel is little more than an organization chart. Design depicted in terms of plant, units, assemblies and components is static, and does not show how any of these were arrived at.

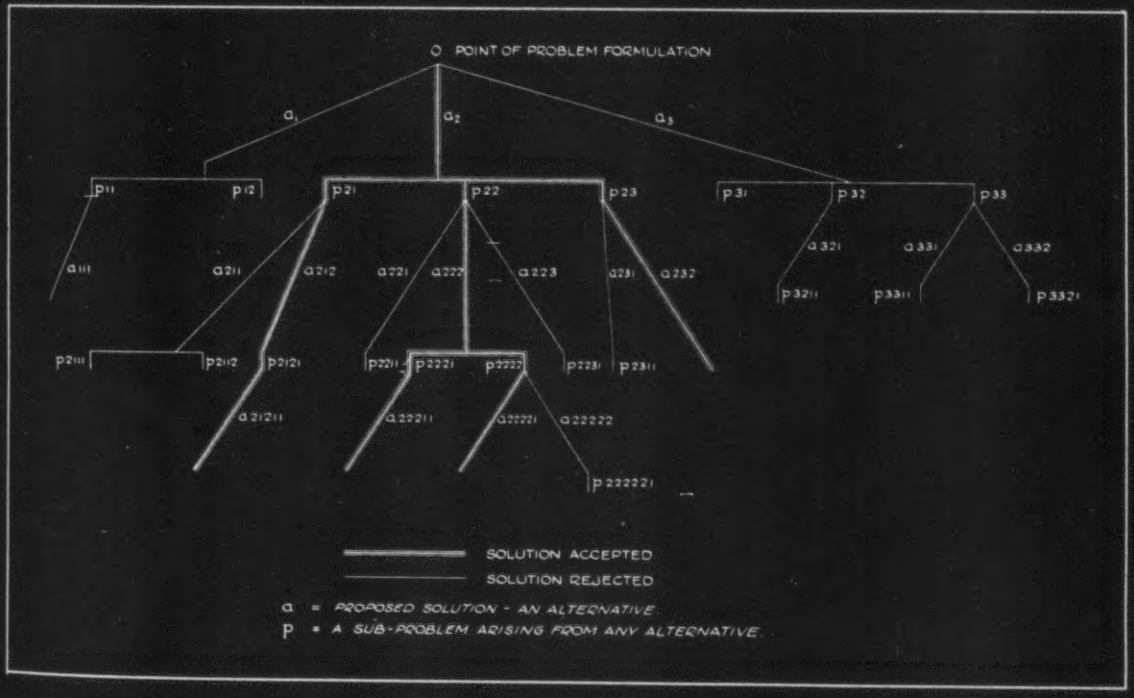
The "Path of a Project" picture (right)* is in terms of time running down the figure, and departments (or personnel) running across. This shows the start of a project; continued into detail design it becomes too complicated to handle or be useful.

Where the project moves to the right and then back to the left, this is approximately equivalent to proposing solutions and evaluating them, then passing the results back for a decision.

The "Decision Tree" model (below)† is also a picture in time which runs down the diagram. The sloping lines represent alternative proposed solutions to the main problem or to sub-problems arising. The short vertical strokes represent the sub-problems which have to be solved (or overcome) if the solution leading to them is accepted. If the problem O is to place a valve in a circuit, then for some solution a_1, the sub-problems p_{11}, p_{12} and p_{13} might be "inaccessibility for maintenance", "assembly difficulties" and "differential expansion". This solution can only be accepted if satisfactory answers to these sub-problems are found; for instance, the use of unusual materials might reduce the importance of the first sub-problem and cure the third; pre-assembly and early installation might answer the second, although the acceptance of these answers will raise other problems.

*Taken from "The Engineering Aid Layout of Chemical Plant", by A. E. T. Hall-Cragoe, Engineering Designer, January 1960.
†Taken from G. L. Harpur's paper.

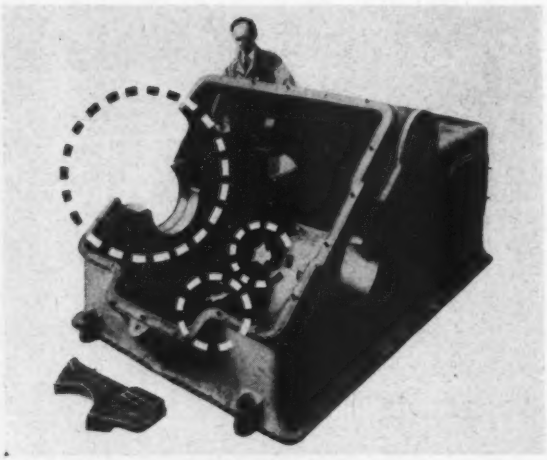



O POINT OF PROBLEM FORMULATION
SOLUTION ACCEPTED
SOLUTION REJECTED
a = PROPOSED SOLUTION - AN ALTERNATIVE
P = A SUB-PROBLEM ARISING FROM ANY ALTERNATIVE

WELDING IS ADAPTABLE —— by TITAN *

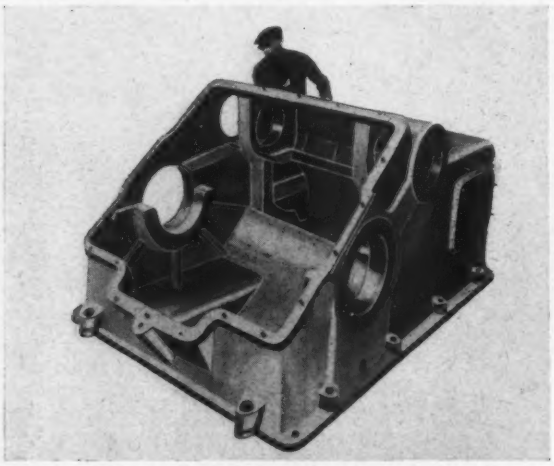
SOME branches of engineering allow little flexibility in their application, but this is a criticism that designers cannot level at welding, which lends itself to all manner of construction with virtually every kind of metal commercially employed. The extent to which engineering production has been influenced by welding methods is profound, and this is reflected in both small components and massive structures, of which the Forth road bridge is only one of many illustrations. Even when no metal is visible, equally large concrete erections are practical only by using welded steel reinforcement.

Just how far designers and engineers can go in applying these methods to a maximum extent has been demonstrated by the construction of a petrol engine from parts fabricated from sheet metal, or flame cut from suitable billets. There are certain machines in regular production that require a great number of gear wheels, every one of which is flame cut. Apart from a little light finishing (but not cutting and grinding), these wheels are put to work without further preparation.



The gearcase shown above is a casting, but it is the kind of equipment that readily lends itself to construction by welded fabrication when in the "design" stage. When it has proved itself in service, patterns can be made and the required number of castings produced. Should any alterations be needed in the prototype, they can be made without much trouble by cutting away portions with a suitable blowpipe and welding in new sections. If a mishap should occur to either a "fabrication" or a casting, scientific welding will soon repair the damage.

The lower illustration shows, better than any descriptive text, how successfully the equipment was repaired by welding. The cost was far below that of a new gearcase.



Owing to the greater flexibility that welding methods permit, there is a special appeal to those branches of engineering that are also artistic, such as the production of metal gates and so on.

An important point to bear in mind is that it is a mistake to design for one form of construction and then apply another means. Invariably, the result falls short of complete success because full advantage is not extracted from the opportunities the particular system offers; this is immensely true of welding. A second aspect of no small importance is the low cost of welding when only one "off" is required. Admittedly, castings are cheaper (although heavier for the same strength) if there is ample repetition over which to spread the cost of patterns, but welding needs no expensive preliminary work.

The most versatile scientific welding engineers are those who are mainly concerned with maintenance and repair requirements. This is because of the infinite variety of jobs, involving all kinds of metal, that they are called upon to undertake. The operators must be highly trained, provided with a wide variety of complex equipment, and be experienced in the application of many special techniques under the supervision of a metallurgical chemist.

In view of this deep practical grasp of the complexities of welding, the services of these specialised firms are widely sought—indeed from time to time calls come from abroad requesting the aid of the mobile squad, so called, to deal with repair problems that are far beyond local talent. A good deal of practical help in undertaking difficult work can be given by firms of this kind. Quite apart from ferrous metals, the extent to which aluminium is welded is considerable. Even magnesium alloys of a type that may be highly inflammable in small fragments can be welded by personnel having the experience and equipment and, above all, a thorough understanding of the special techniques that must be applied. Copper as thin as 18 s.w.g. can be welded by means of the argon-arc process, resulting in a non-porous pressure-withstanding joint.

Inspection is of paramount importance, for without adequate organisation in this respect a guarantee is virtually impossible. In this connection gamma rays are of great value in that they allow the weld metal to be inspected throughout its depth. Thus not only is quality and freedom from inclusions ensured, but also the depth of penetration of the new metal into the parent material, which is vital to success.

Occasionally it happens that some special conditions prevent the use of heat. In such instances, particularly if castings are involved, it is usually feasible to apply a mechanical means of repair known as metal "stitching". Ample strength can be obtained in this manner, and the result is guaranteed in the same fashion as a straightforward welding job.

The flexibility of welding processes, coupled with freedom from many restrictions which hamper designers employing certain other forms of fabrication, render welding a source of aid that none can afford to ignore, whether they be concerned with new equipment, modifications to existing plant, or normal needs for maintenance and repair.

* *Works controller, Barimar Ltd. (scientific welding engineers).*

THE GYROSCOPE AND ITS USES

The author commences with a description of the gyroscope and its properties. He then comments on various applications, such as its use in navigation, in equipment for measuring undulations in roads and railways, and in investigating the behaviour of car suspensions

by J. TINDALE, M.I.Mech.E. *

MANY past applications of the gyroscope have been connected with military equipment, the actual details of which have not been published for security reasons. Because of this, engineers might have been discouraged from interesting themselves in its possibilities as a control device or basic reference. They may even look upon it as a scientific freak and have only a vague idea of its working, and the possibility of its wider uses may consequently be overlooked.

Before embarking on a description of its applications, it is considered worth while briefly to introduce the details of the gyroscope to the reader. It consists of a spinning wheel turning at a high speed. Its spin bearings are usually supported in a double gimbal frame supported on trunnions (see Fig. 1). The useful property that a gyroscope has is that of staying put angularly in space. When mounted in gimbal frames permitting it two degrees of freedom whilst spinning about a third axis, it will remain stationary about the two axes.

The wheel may be driven by fluid such as gas or liquid as a turbine is driven, but generally it is powered by an integral electric motor. This takes the form of a squirrel cage induction motor arranged in a special manner so that the rotor (squirrel cage) envelops the stator. The stator is furnished with a three-phase winding which, as it is stationary, needs no slip rings—a good point with a motor speed of 20,000 r.p.m., in the case of 330 c/s supply (see Fig. 2).

As the gimbal frame must be supported on the earth or on some body (ship, aircraft, vehicle) mounted on the earth, it will appear to move relative to its outer gimbal frame owing to the latter's connection with the earth, which is turning in space. If the gyro spin axis points at right angles to the earth's axis, then it will appear to move at the speed of rotation of the earth (see Fig. 3) about an axis parallel to the earth's axis. This speed is 360° in 24 hr., or 0·000073 radians/sec. Any other aspect will give a corresponding component of this relative rotational speed about the earth.

A gyro can be made to move spatially by applying a torque about either of its gimbal axes. The application of such a torque causes the gyro to move at an angular rate proportional to the applied torque and at right angles to it. This is called precession.

If it is desired to use the gyroscope as an earth's reference, for example a horizon or vertical reference, then it is possible to apply a torque to cause movement equal to the earth's rotation, so that no relative movement occurs. Let us see what this means.

The property of remaining stationary is due to the gyroscope's angular momentum, which is equal to the product of the polar inertia of the wheel about its spin axis and its speed of spin = $I\omega$. For example, a gyro wheel is 4 in. dia., has a mass of 4 lb. and a radius of gyration of 1·3 in. The polar inertia = $I = MK^2 = 0{\cdot}047$ lb. ft.^{2} If the speed is 1,800 radians/sec. = ω, then the angular momentum $\frac{I\omega}{g} =$ 2·7 lb. ft. sec.

If it is required to annul the relative motion due to earth's rotation, the torque to be applied is given by the expression $T = \frac{I\omega}{g}\Omega$, where Ω is the rate of angular precession resulting from the applied torque. Substituting values, $T = 2{\cdot}7 \times 0{\cdot}000073$ lb. ft., or = 0·04 oz. in.

A 4 in. dia. wheel gyro is quite a large instrument, and 0·04 oz. in. torque is very small. It will be fairly evident that to obtain proportionality the friction in the gimbal bearings must be of a very low order indeed, since it will have to be overcome before the applied torque is felt as a precessional torque.

Any frictional drag caused by relative movement between the gyro and its gimbal bearings caused, say, by the earth's rotation, will act as a precessional torque and will induce a wander rate to develop which, in the course of its development, will alter its aspect as the inner gimbal gets out of quadrature with its outer. Such changes in torque are always certain to be random, and to be impossible to compensate satisfactorily.

Reduction of Friction in the Gimbal Bearings

Various methods have been devised to reduce the effect of friction in the gimbal bearings. Very accurate low friction ball bearings are used for most applications, but for special purposes air bearings[1] have been found advantageous. These comprise a plain bearing of sufficient diameter to support the gimbal weight with air at say 30 p.s.i. forced through holes in the lower half. For such an example a 15 lb. mass would be supported on a projected area of 1 sq. in., assuming a linear pressure gradient across the supporting surface.

* *Assistant joint general manager of Elliott Brothers (London) Ltd.*

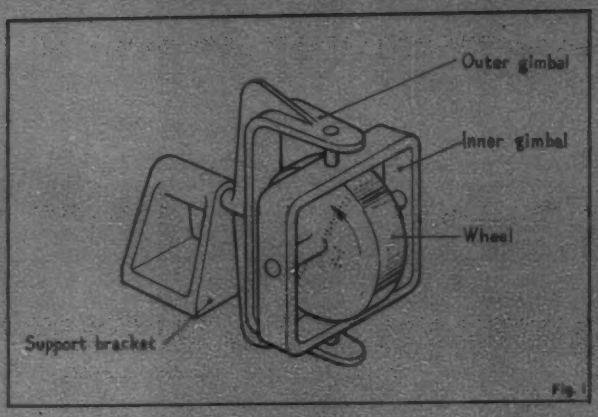


Fig. 1

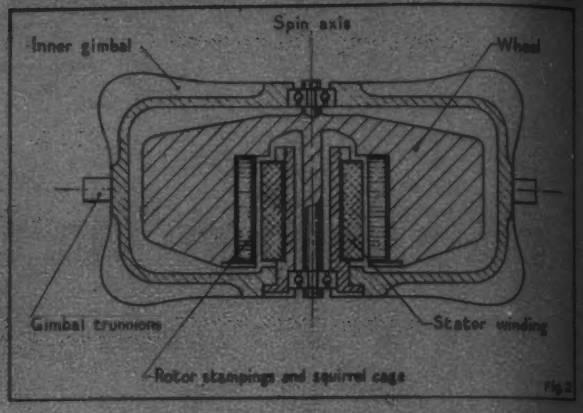


Fig. 2

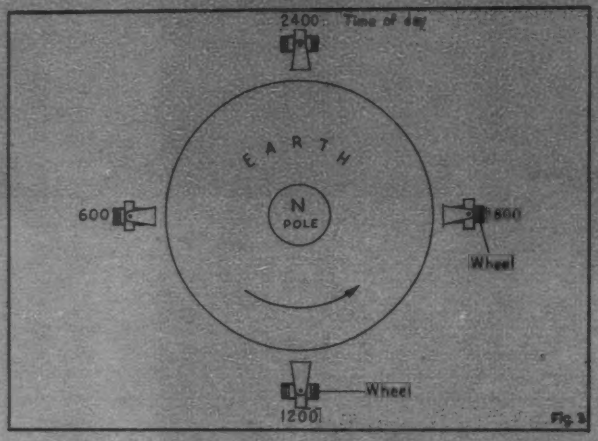


Fig. 3

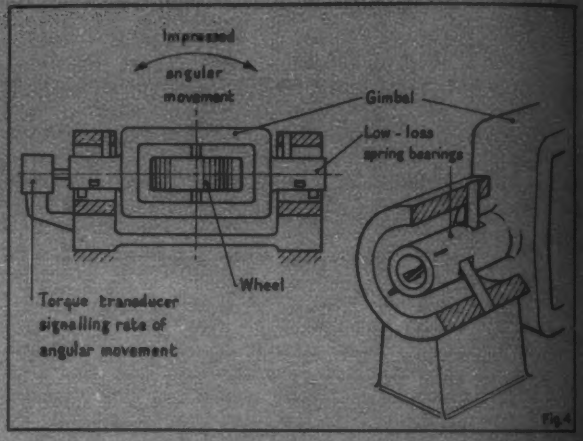
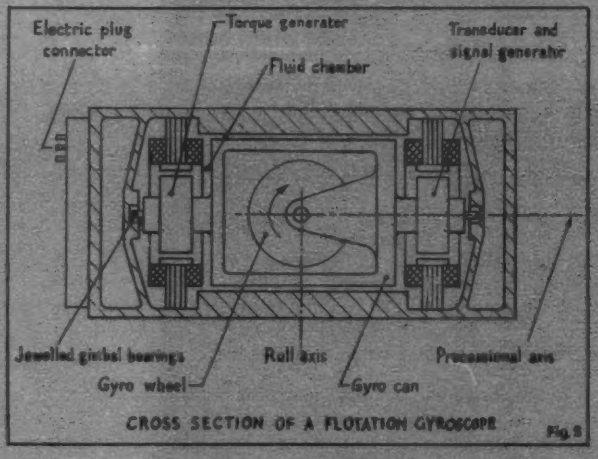


Fig. 4



CROSS SECTION OF A FLOTATION GYROSCOPE
Fig. 5

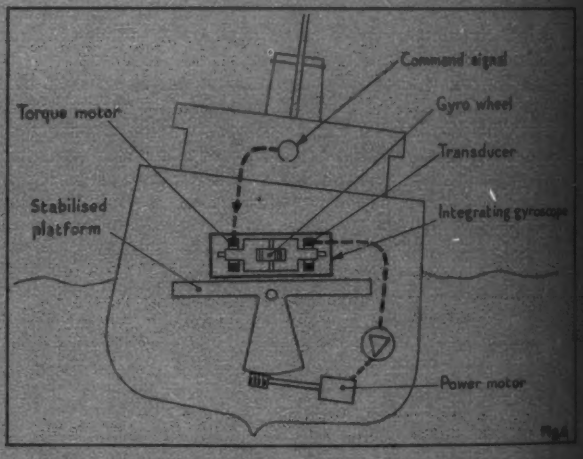


Fig. 6

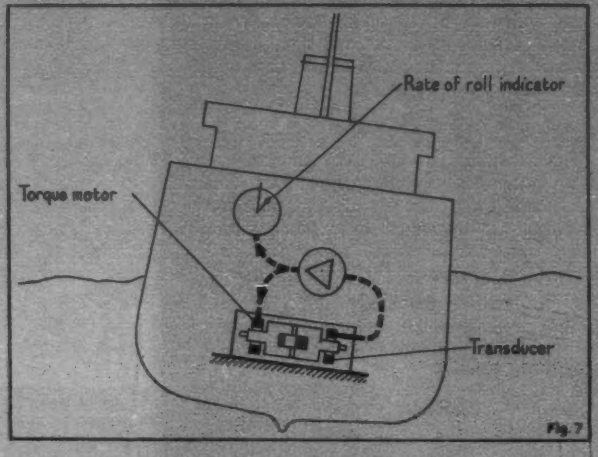


Fig. 7

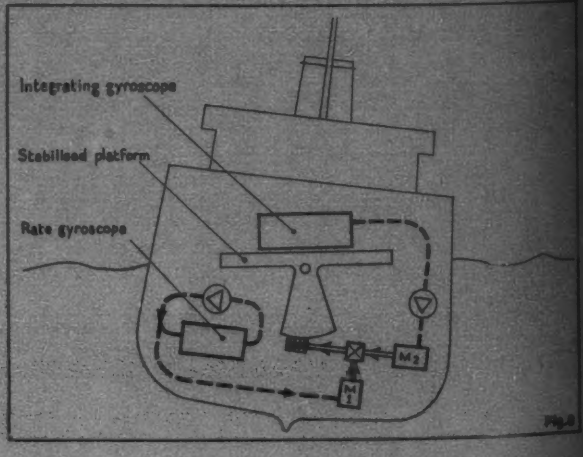


Fig. 8

Provided that the gyro is not subjected to shock, air-bearings are very satisfactory, but the ancillaries are expensive. These comprise an air compressor, a dryer and a filter, and according to the weight of the system a considerable amount of air may have to be blown into the bearing.

Another method less susceptible to shock is to use ball bearings, but to support the weight of the gimbal by means of a magnet.[2] The load on the bearings is thereby balanced and the resultant frictional torque is only felt during acceleration on the gyro system. Unlike the air bearing, which is comparatively larger in diameter, the momentary use of the ball bearings as a support and guide during accelerations does not unduly disturb the stability of the reference.

For purposes in which the earth's reference may be required for relatively short periods of time, the wander rate of the gyro caused by friction of high quality ball bearings, not compensated in any other way, can be accepted, since the accumulated error will be within the tolerable limits of the desired accuracy over the period of measurement.

For long-term reference such as submarine navigation, during which a secondary check reference such as a star may not be obtained conveniently, special types of gyros have been developed in which the effect of friction has been reduced to negligible values. This will be referred to later, as the reader first should be informed that another very useful property of the gyroscope exists. This is an extension of the property that it has of moving at an angular rate proportional to the applied torque.

If the gyroscope is constrained from moving about one of its gimbal axes, and is subjected to an angular rate about the other axis, then a torque reaction occurs about the first axis proportional to the applied rate. This reaction can be measured by springs or pressure transducers, and thereby used to reproduce a signal proportional to the angular rate. It can even cause a secondary (phantom) gimbal system, enveloping the sensitive gimbal system, to be power driven to synchronise with the movements of the gyroscope.[3] This provides a platform from which abutments for applied torques can be arranged, and also serves as a base for transducer measurements. The axis about which no movement is allowed may be supported by elastic constraints so that only molecular friction is present. By suitable design the hysteresis in these supports is reduced to a negligible quantity (see Fig. 4).

Flotation Gyros

For very sensitive and accurate applications a range of so-called flotation gyroscopes[4] has been developed. These are mostly designed with one degree of freedom. That is they are capable of limited movement about one gimbal axis only. The wheel is contained in a hermetically sealed can which serves as a gimbal, outside which trunnions are fitted. These trunnions comprise small diameter pins supported by jewelled bearings fixed to the inside of the containment vessel. Between the containment vessel and the gimbal-can is attached some form of pick-off or transducer to detect movement of the gimbal relative to the containment vessel (see Fig. 5).

To reduce friction of the jewelled pivots, the gimbal-can is floated in a liquid, the density of which is such that the displacement exactly balances the weight of the can and its contents. Thus no weight is carried on the jewels, and therefore no frictional torques exist which would otherwise have been caused by the weight on the trunnions. The annular space between the can and the containment vessel is only a few thousandths of an inch thick, and is completely filled with the supporting liquid. If the gyro is subjected to shock such as might be caused by the acceleration due to rocket propulsion, the support of the liquid on the large area of the can acts to prevent shock forces being imparted on to the jewels. In addition, the design arranges for the centre of buoyancy and that of gravity to coincide, thus obviating accelerating couples.

These flotation gyros may be used for a variety of purposes. One use would be to act as a signal device to maintain a platform stable in space. For complete stabilisation about three axes, three units as described would be required to produce a stable element. For the purpose of simplicity in describing the method used, stabilisation about one axis only will be considered.

It is required to stabilise a platform mounted on a ship with bearings arranged along the ship's axis so that relative movement of the platform can be annulled by giving it equal and opposite movements to that of ship's roll by means of a power motor (see Fig. 6).

The flotation gyro is mounted with its jewelled bearings at right angles to the axis of roll. A roll imparts itself to the gyro, which precesses about its jewelled bearings axis. The transducer senses this precession as a torque or departure, and causes the motor to drive the platform to counteract the roll movement, and so stabilise the gyro in space. The gyro therefore ceases to precess, as the impressed rate has been neutralised, and the signal from the transducer is kept at values that maintain stabilisation of the platform. Thus the rate of roll is counterbalanced by an integration of error signals caused by acceleration. The gyro used in this form is called an integrating gyroscope.

To use a gyroscope as a rate measuring device, it is mounted similarly as described for integrating purposes, but it is fixed to the ship and is not stabilised. The impressed roll causes the gyroscope to precess, and this gives rise to a voltage generated by torque transducer proportional to the rate of the impressed roll (see Fig. 7).

It is sometimes advantageous to combine an integrating gyroscope and a rate gyroscope[5] to control a large power system stabilising a platform (see Fig. 8). The rate gyro produces a voltage proportional to the roll speed, and controls the speed of one power unit. Any error in the stabilisation of the platform is sensed by the integrating gyro which is mounted thereon, and the error signal is used to control a second power unit to differentially add to the stabilising movement to complete the stabilisation of the platform.

Aids to Navigation

One of the first useful applications of a gyroscope was for ship navigation.[6] By making a gyroscopic gimbal system pendulous at right angles to the spin axis and therefore influenced by gravity, the effect is to introduce precessional torques to cause the gyro's spin axis always to be pointing towards the north wherever it may be. The spin axis of the gyroscope, therefore, will always be horizontal to the surface of the earth, and contained in the same diametral plane as the earth's axis.

When used as a navigational aid in aircraft, the ship type of gyro compass, with its north-seeking gravitational control, cannot be used owing to the complex accelerations which accompany such movements. Nevertheless, gyroscopic aids are used for short-term stabilised heading, together with an artificial gyro horizon or vertical reference.[7] Such gyroscopes are in complete neutral balance so that they will not be influenced by linear accelerations.

The latest type of inertial navigation instruments used by submarines and long-distance aircraft employ the flotation gyroscopes referred to, or something equivalent[8] (see Fig. 9). They are compensated for all known and measured movements such as linear velocity and acceleration, latitude, corrected earth's rotation, etc. Since the frictional drag of these gyroscopes is negligible, they provide an absolute spatial reference over long periods of time.

Stabilisation of ships against roll has been effected in one instance by coupling a huge gyro to the ship's structure.[9] A small rate measuring gyro controls a large hydraulic ram which applies a torque to the large gyro, causing it to pre-

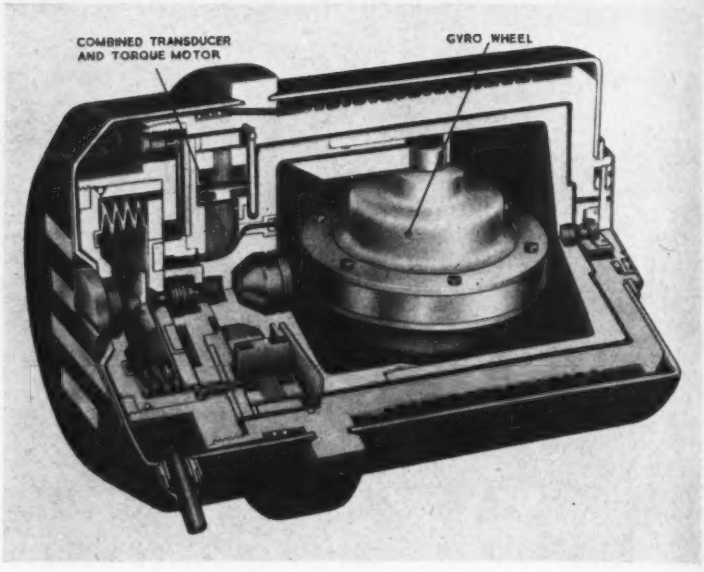


Fig. 9. Cutaway view of a new helium gas-bearing ceramic gyroscope developed from flotation gyros by the Massachusetts Institute of Technology, and introduced by Minneapolis-Honeywell for missiles and space vehicles (see references 4 and 8).

cess counter to the ship's roll and so carry the ship with it in opposition to the applied roll forces caused by the sea waves.

Another method being used most successfully is that of having swivelling fins projecting from the sides of the ship.[10] The ship's forward movement through the water, coupled with the inclination of the fin controlled from a roll indicating gyro, exercises a righting moment to the ship.

Applications

It may not be generally appreciated that one of the first applications of the gyroscopic principles was the rifling of a gun. Previously, ball ammunition was used, but with the advent of the explosive shell it was necessary to make sure that the shell nose arrived first, since it contained the fuse. The spinning of the shell caused by the rifling in the barrel biting into a soft copper ring at the base of the shell achieved this object. It also so improved the trajectory that the principle was extended to small arms, for example the rifle bullet.

With the modernisation of the railways, the maintenance of the track is of great importance. By the use of a high-speed recording coach[11] the condition of the track can nowadays be continuously surveyed. One of the measurements made is the cant of the track, which is necessary for safety on curves. By using a gyroscope to give a vertical reference, this can be measured to an accuracy within a few minutes of arc. This is achieved over long periods of time by applying compensating torques to the necessarily pendulous gyro for centrifugal force, gradient and curvature, linear accelerations and earth's rotation. The latter requires also the speed of the coach, its direction and latitude position to be determined, to give the true relative component of the earth's rotation. This may seem complicated, but it does provide an absolute measurement of the vertical within acceptable limits.

The condition of the main trunk roads is also of vital importance, since the development of a very small wave can be uncomfortable at high speeds, and a longer wave dangerous. The recording of an undulating surface may be carried out by using a gyroscope as a reference in a similar manner to that used on the railways.

The behaviour of car suspension may be measured and recorded by the rate gyroscope, which will measure the rate of roll or pitch of a car body travelling at speed along various characteristic surfaces.

The study of coast erosion can be expedited by reference to gyros mounted on a perambulator or a towed vehicle. Records of beach topography may be made after each tide, thus providing statistical information in less time than a theodolite or level survey.

In mining, tunnelling or boring, where it is difficult to obtain external fixes by theodolite, a gyro compass may be used in the determination of the meridian grid.[12]

Although it is usual to think of the gyroscope in terms of a mechanism, the principle of the gyrostat may be applied to things other than machines. Such a device has recently been invented in connection with measurement of the mass-flow of liquid.[13] Briefly, the liquid is fed into and out of a conduit bent in a circle. The entrance and exit being at the centre of the circle. The input pipe runs out radially until it enters the circular portion, and the return exit pipe runs radially adjacent to the input pipe. Two axes of rotation are arranged at right angles to each other and in the plane of the circle. A constant vibration is given to the one axis, which results in a precessional torque about the other. Since the mass-flow can be represented by $I\omega$, and the vibration by Ω, the torque measured by a pressure transducer is proportional to the mass-flow as represented by $T = (I\omega)\,\Omega =$ (mass-flow) $\times$ constant.

This example helps to illustrate the versatility of the gyro, and it may be that engineers in other industries will be able to apply these principles to solve their particular problems in new and elegant ways.

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11. "British Railways Track Recording Vehicle", *The Railway Gazette*, August 1959.
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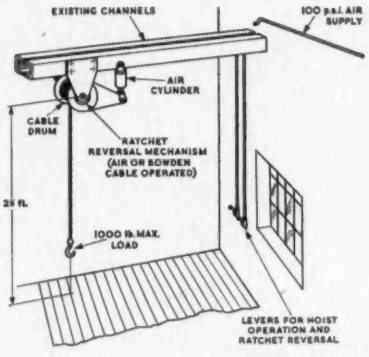
PROBLEMS IN DESIGN

Problem No. 16 (February): A works engineer's sketch of a hoist, to be operated by a single compressed air cylinder, is shown. The device is wanted in a hurry at the minimum expense, without gears. No electrical controls are permissible.



Provide a more detailed scheme, embodying the main features, together with the air-line circuitry to be used.

The entries received for the above problem were few in number and disappointing in quality. We feel that our readers were probably deterred by the safety aspect of the problem. On the other hand, some may have thought that as air-operated hoists already exist on the market the problem was therefore unrealistic, as such a hoist would undoubtedly be purchased off the shelf.

The problem is rather more difficult than might at first sight appear, for the reason that the load must at all times be securely held by some locking device. While the reversible ratchet is commonly used for the operation of vertical screw jacks, the problem of holding the load, while the ratchet action is reversed, does not arise, as the load is taken via the screw threads into the base of the jack and there is little tendency to rotate the ratchet nut. It appears, therefore, that for a hoist to be designed along the lines given in our sketch, a reversible anti-feedback device must be incorporated within the mechanism which will allow the drum to be rotated in either direction, but which will prevent the ratchet pawl being under load when reversal takes place.

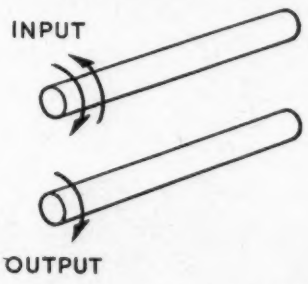
A particularly ingenious method of solving this problem is seen in the manually operated chain hoist known as the Rotolift, an exploded view of which is shown. In this hoist, the handle (1) is provided with a selector lever (2) which causes either one of two pawls to engage a right- or left-hand lifting ratchet (items 3 and 4). The lifting gear spindle (5) is screw threaded to fit the inner lifting ratchet (4). It will be seen that at the point of ratchet reversal, or in the event of ratchet failure, a very slight rotation of the lifting gear spindle will cause this item to screw itself into the inner ratchet (4) and in so doing draw together the component parts of the friction clutch, one plate of which is designed with projections which fit into the body member. The manufacturers of the Rotolift, **G. Hunter (London) Ltd.**, do not feel that it lends itself to redesigning as an air-operated hoist, probably owing to the lack of sensitivity in control attainable with air operation.

An alternative way of preventing feedback torque to the ratchet mechanism must therefore be found and one interesting device, at present being manufactured by **Renold Chains Ltd.**, of Manchester, and known as the R-L clutch would appear to be suitable for the purpose. Somewhat resembling a sprag clutch, it eliminates feedback torque, provides two-directional positioning and operates to lock with a very small (2½-3 deg) arcuate movement. The part-sectional drawings show how the device works. The end of the input member has a series of projecting control elements evenly spaced around its diameter. Each of these control elements projects between a pair of opposing sprags. When the input member is rotated in either direction, these control elements first disengage one set of sprags at (1) and then drive the output member through the base area at (2) of the same set of sprags. The complement of sprags (arranged in opposing pairs to provide instant wedging against feedback torque) are in reality a part of the output assembly. A garter spring passing through the sprags ensures instant engagement for either direction of rotation.

It would appear logical, if this component were employed, to position it so that the outer race was held stationary by one of the cheek plates carrying the hoist spindle. The R-L clutch is provided with two ball bearings and is therefore

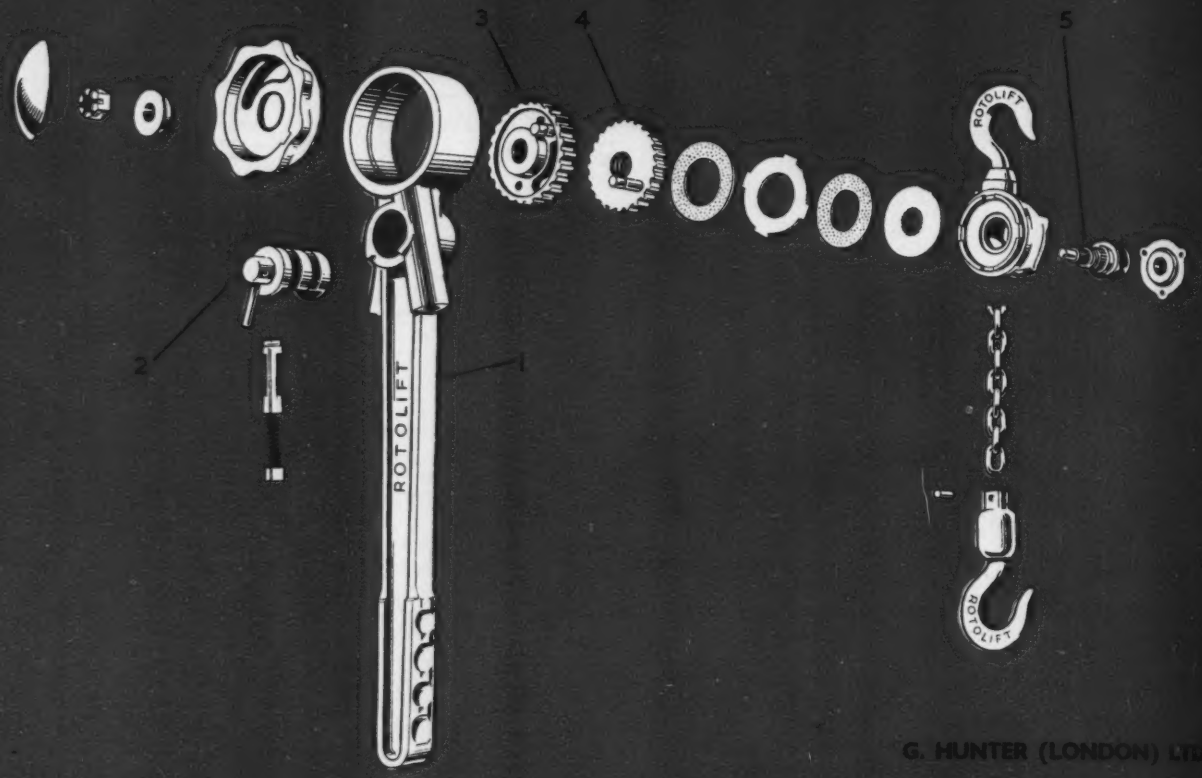
PROBLEM IN DESIGN No. 20

Here is this month's problem

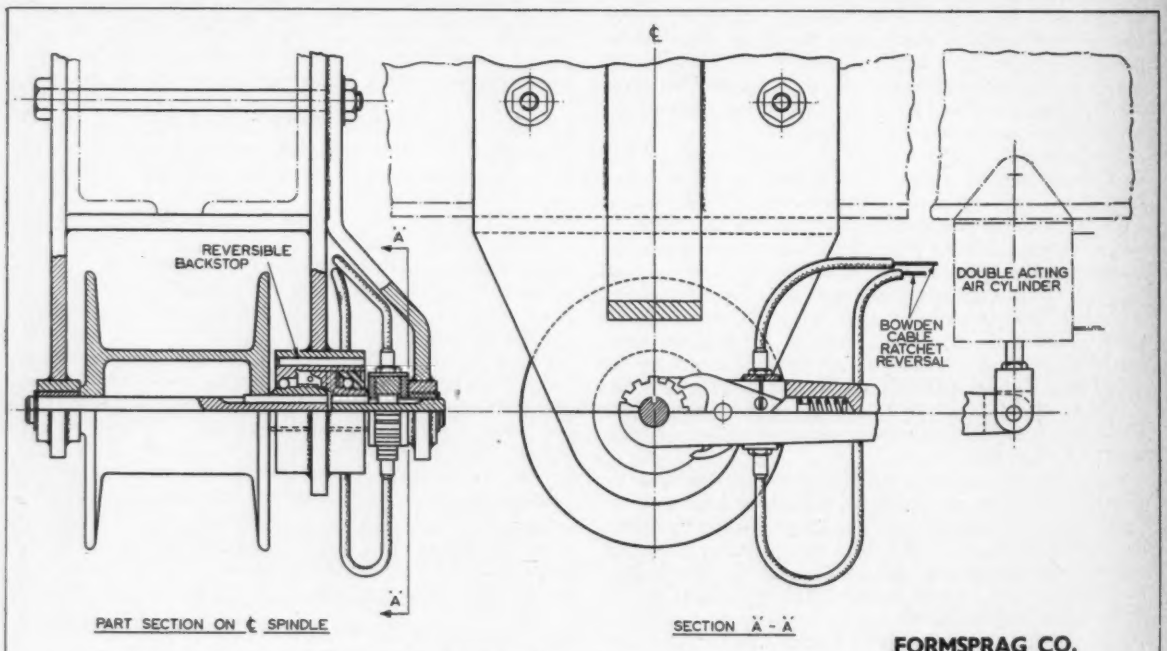


Devise a mechanism which will enable an input shaft, the direction of rotation of which may be subject to reversal, to transmit unidirectional rotation to a shaft parallel with it regardless of its own direction of rotation.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian Ink and not more than 12 × 12 in., please!), to the Editor, "Problems in Design No.20 (June)". Closing date July 20.



G. HUNTER (LONDON) LTD.



FORMSPRAG CO.

SCHEMATIC LAYOUT OF AIR-OPERATED HOIST

self-supporting. On the input side, the reversible ratchet mechanism, operated by a bowden cable, would be mounted while a double-acting air cylinder would operate much as in the original sketch. The cable drum would be carried on a shaft, keyed to the output side of the Rev-Lok, and carried in a plain bearing on the opposite side of the stirrup bracket (see schematic layout). As an alternative to a reversing ratchet, the Dual Drive manufactured by **Tiltman Langley Ltd.**, of Redhill, might be considered. This is a form of reversible clutch which only requires a very small arcuate movement of a control wheel to reverse the action.

It may be objected that as an air-operated hoist already exists on the market, the obvious course would be to order this in preference to making one. For those who might wish to adopt this course, to ensure that there was no contravention of the Factories Act, the air-operated hoist by **Martonair Ltd.** could be used.

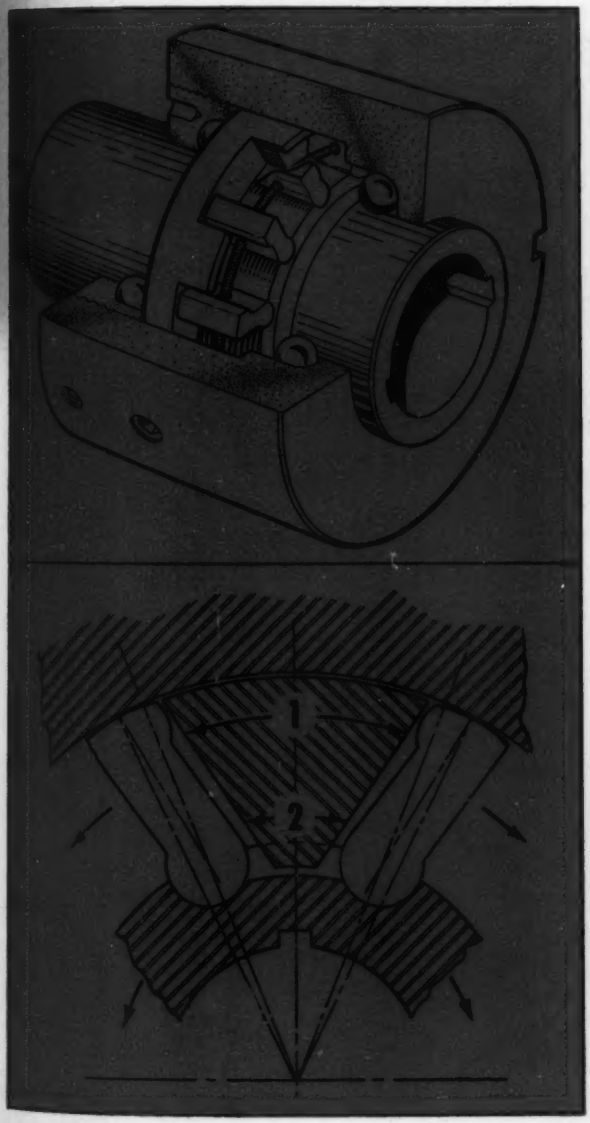
In the case of a single-cylinder version, as shown, the hoist consists of a cylindrical body inside which there are two sheave assemblies. One of these is the stationary sheave assembly which is attached to the hoist body. The moving sheave assembly is attached to a piston operated by compressed air, which is admitted at the hoist control side. The load-carrying hook is attached to a cable which passes over the stationary sheave, then over the moving sheaves to its anchorage point on the hoist body.

When one trigger of the control valve is depressed, air forces the piston to the right, whilst depression of another trigger moves it to the left. When the piston moves so does the sheave assembly which is attached to it. Because the hoist relies on the positive displacement of the operating piston, the air pressure in the hoist for any given load is proportional to the load. The actual relationship between these two factors depends on the diameter of the piston and the number of pulleys in the sheave assembly. Thus, for a particular cylinder and stroke length, a small number of pulleys results in a relatively high load capacity and a short lift; a large number of pulleys results in a low load capacity and a long lift.

As the Martonair hoist balances the load against the air pressure acting on the piston, it is possible to manhandle the load up and down within limits—a useful feature.

For a 1,000 lb. load a four-cylinder version of the Martonair hoist would be necessary.

THE R-L CLUTCH (RENOLD CHAINS LTD.)



MARTONAIR LTD.

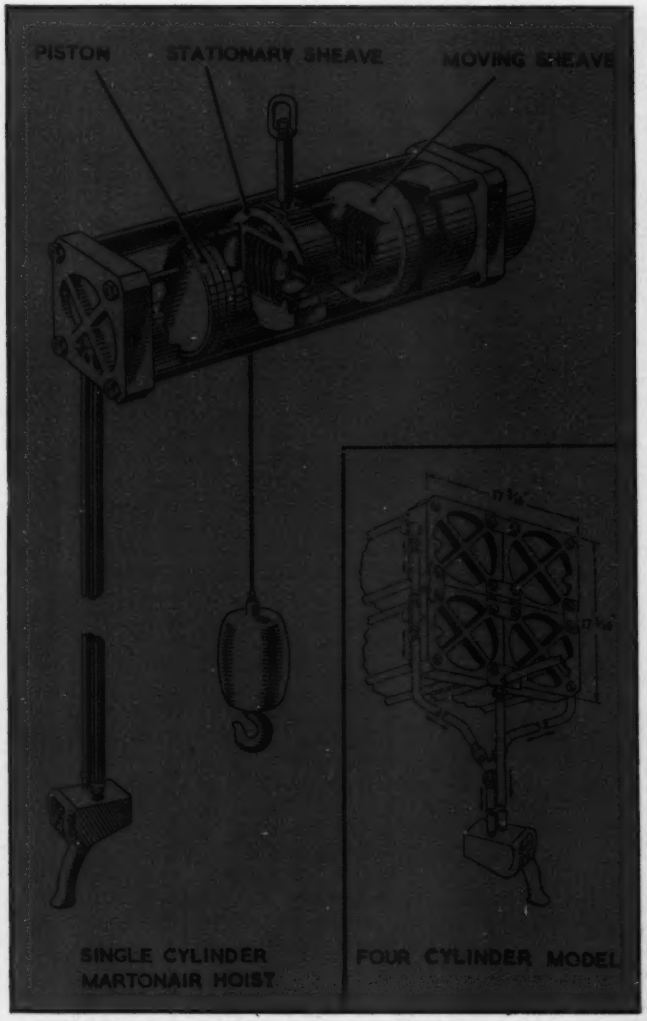


Fig. 1. An elementary roller type freewheel. Oscillation of the outer ring causes intermittent unidirectional movement of the driven ratchet wheel.

Fig. 2. An early type of freewheel used in the freewheel engine of Otto-Langen.

FREEWHEELING DEVICES – PART 1

An outline of the operating principles of various types of freewheel is followed by a survey of components available from seven main suppliers

THE principle of the roller-type freewheel or silent ratchet has been known for many years, and a simple form of this device is shown in Fig. 1. An intermittent oscillating motion of the outer ring brings about a corresponding intermittent unidirectional motion of the driven ratchet wheel. Clockwise rotation of the outer ring causes the rollers to ride up the cam surfaces until locking is achieved, while reversed rotation of the outer ring frees the rollers and enables freewheeling to take place.

Reference to the relevant files at the Patent Office reveals a host of recent variants on the freewheels which have been invented in the past. Fig. 2 shows an early type used in the freewheel engine of Otto-Langen. The subject still seems to hold the attention of inventors.

In recent years this simple device has been considerably developed, and a number of manufacturers produce clutches of this sort which are by no means limited in their functions to the simple ratcheting action described above. They are made either in ranges which can be bought "off the shelf", or produced to suit special applications. In addition to refined versions employing springs in the individual rollers to ensure minimum angular lost motion on reversal, there are also versions which employ wedge pieces or sprags in place of rollers, and some which employ a centrifugal type of element designed to engage or disengage when a certain speed is reached. Then there is a more recently developed type which provides for drive in either direction. A close study of both standard and special versions, and what they are capable of, can sometimes bring to mind elegant solutions to existing problems, or suggest new applications.

The principal simple uses of the sprag or roller types of freewheel are backstopping, indexing, and overrunning. These are illustrated in Fig. 3. At *A* the freewheel is used as a backstop on a bucket conveyor to prevent backward movement when the motor stops. At *B* a simple indexing device is shown, and *C* illustrates the use of a freewheel in the drive of a large fan, where it is sometimes necessary to enable the fan to continue running after the current to the motor has been switched off.

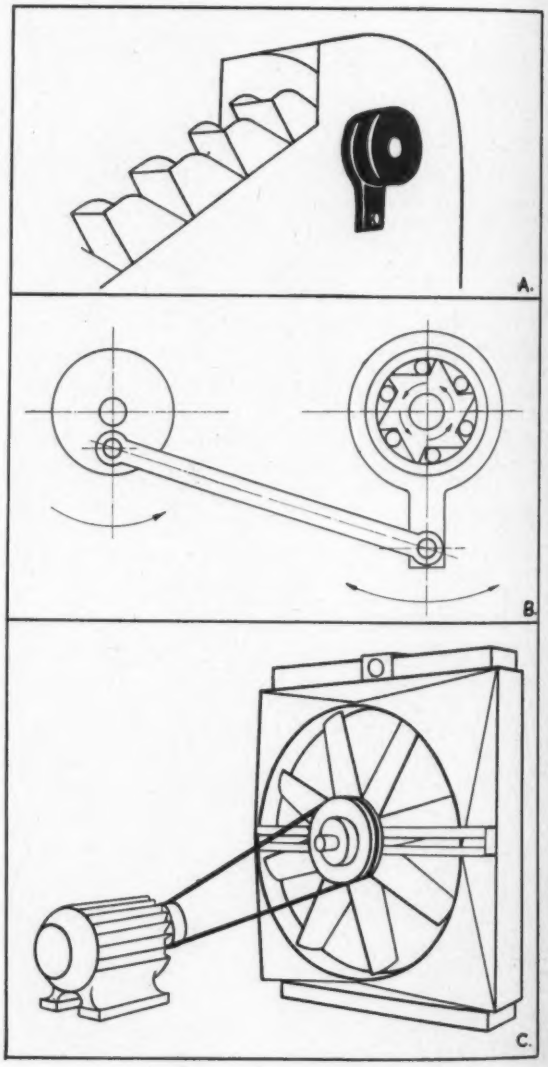


Fig. 3 (*right*). *A*—Application of a freewheel to a bucket conveyor to prevent backward movement in the event of motor failure; *B*—A simple indexing device employing a freewheel; *C*—Application of a freewheel to a fan drive to enable the fan to continue running after the motor is switched off, thus preventing belt breakage (from a Renold technical information sheet).

Many other examples of the above three functions come to mind, and in recent years more sophisticated variants have appeared. Thus, Fairbairn Ulro Ltd., of Leeds, have produced an infinitely variable positive drive gearbox, having no gears, by incorporating two freewheels (see *E. M. & D.*, September 1960, p. 563). Renold Chains Ltd. have published an excellent handbook showing numerous applications of their range of sprag clutches for automobile transmission, electric motor drives, gearboxes, automatic indexing of punch press material, farm machinery and many other uses.

Borg-Warner Ltd.

The Borg-Warner one-way clutch employs the sprag clutch principle, the sprags being held in two circular cages by means of a ribbon spring of stainless steel (Fig. 4). This spring is accurately formed, and is claimed to ensure uniform engagement of all the sprags combined with minimum freewheeling drag. The clutches supplied by Borg-Warner do not include the inner and outer races. The units available consist of the inner and outer cages, the sprags and the ribbon spring.

Among the advantages claimed for this type of clutch is that, under shock load conditions, the sprags act simultaneously and are forced to act in unison. This is assured by the close fit of the contoured sides of the sprags in the cage windows. Borg-Warner emphasise that, beyond a certain point, it does no good to put additional sprags between weak races, since the controlling resisting force that determines torque carrying capacity is the hoop strength and rate of stretch of the race, and not the number of sprags involved. The core and outer areas of the race must be ductile enough to be tough and of high elastic strength to obtain maximum torque capacity. It is recommended that the core hardness for the outer race should range between Rockwell C 43-48. Heat-treatment should be such that there are no undesirable transition zones between the tough high-strength outer areas and the harder face areas of the races. Similar values apply to the material used for the core of the inner race. It is recommended that the wearing faces of the races should be about Rockwell C 62 hard. Suitable bearings must be provided to maintain and control the space between the races if minimum freewheel wear and reliable high torque capacity are to be obtained.

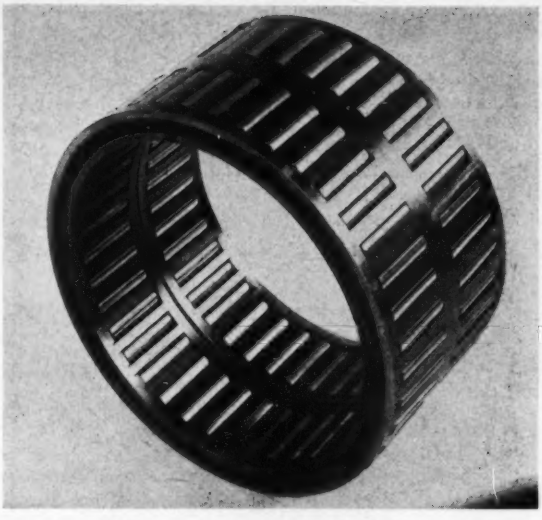
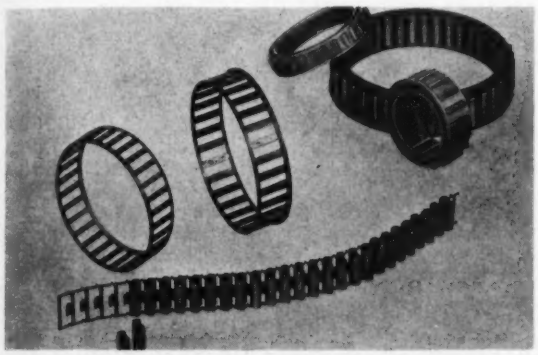


Fig. 5. Twin row Borg-Warner full phasing one-way sprag clutch, developed for the Hillier helicopter H-23. Static load capacity is 100,000 in. lb.



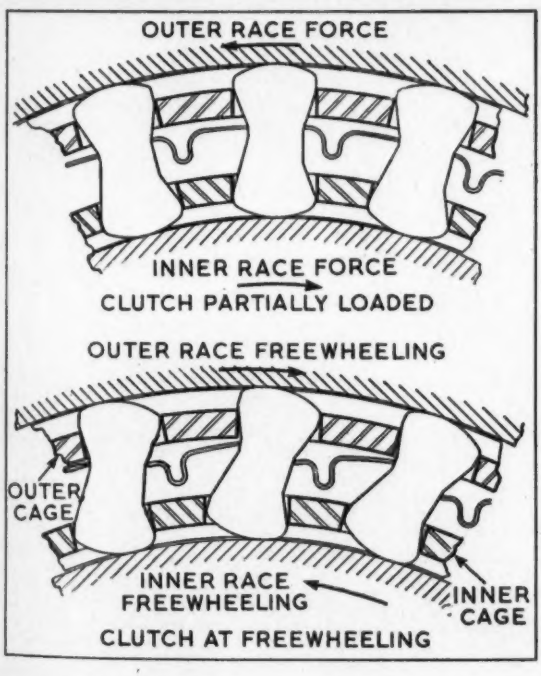


Fig. 4 (*left*). Components of the Borg-Warner full phasing sprag clutch, which is supplied for fitting to customers' own shafts and outer races.

In addition to the ordinary kind of sprag, which relies on friction to bring about engagement, the clutches can be supplied with special sprags in which the centre of gravity is so positioned that there is a tendency to lift off the inner race at high rotational speeds. In another type, engagement with the inner race occurs with increased speed. The freewheel drag is normally limited to 2 oz. in. per in. of sprag length. It is pointed out, however, that this figure can be varied to suit the application.

Another feature which is available if required imposes a small amount of drag on the inner and/or outer races. This is accomplished by slotting the outer cage side bars at two points, as shown in Fig. 6, and bending the segment to cause slight interference between the cage and the adjacent race. Alternatively, a spring is incorporated on the inner race to provide frictional restraint. The drag of one cage is set higher than that of the other, so that the clutch is frictionally held to either race as desired, and slides on the other race. The design drag of the sliding cage is sufficiently high, as compared to the drag imposed on the sprags by the light energising spring, to enable the sprags during freewheeling to ride very lightly on the races. It is claimed that this "built-in drag" feature can more than double the life of the clutch where extensive freewheeling is encountered.

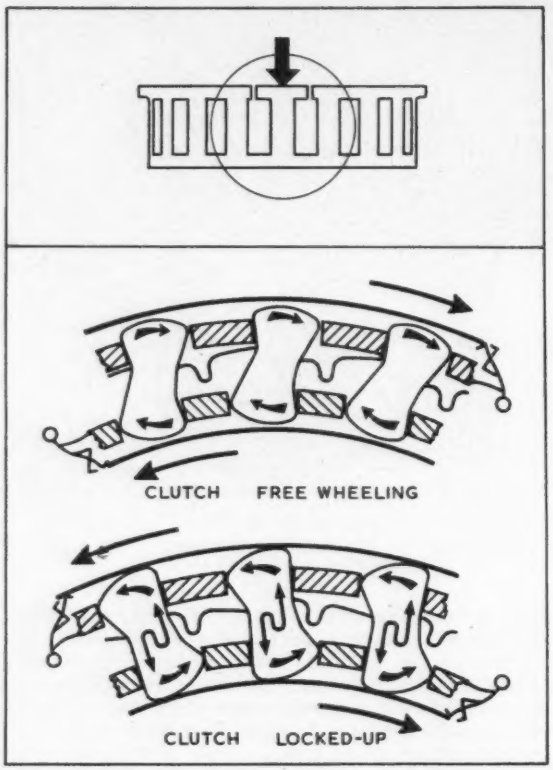


Fig. 6. Borg-Warner clutch fitted with built-in drag, an optional feature to eliminate wear.

Range

The range of double-cage full-phasing one-way clutches produced by Borg-Warner is a large one. (It should be remembered that the inner race diameter referred to below is the outside diameter of the inner race, and the outer race inside diameter is also given. Recommendations are given for the minimum outer race outside diameters, to ensure that adequate bursting strength is available.) The sizes of clutches indicated are available with or without the built-in drag feature, operating on the outer or inner races, or both. In addition, the range of sizes can be supplied with normal or centrifugal type sprags.

Inner race diameters range from 1·0930 to 4·6217 in., with corresponding outer race inside diameters ranging from 1·7490 to 5·3697 in. (The minimum outer race o.d. for the 1·7490 in. outer race i.d. is 2·25 in., and for the 5·3697 in. outer race i.d. is 6·90 in.) For each of the nineteen sizes coming in this range there are six axial lengths available, from 0·530 to 1·000 in., except for the two smallest sizes, which are only available up to 0·875 in. in axial length. Clutches can be manufactured to cover the range from 103 to 4,060 lb. ft. In addition, clutches can be made to special order, such as that shown in Fig. 5 (this is a tandem version which would be used for transmitting torques in the order of 8,000 lb. ft.).

To cater for high freewheeling speeds, in the order of 15,000 to 20,000 r.p.m., as encountered in gas turbine starter applications, any particular clutch can be made to disengage at a particular speed. Clutches can also be supplied having either journal bearings or alternate sprags and rollers for low torque applications where there is a limit on the axial space available for the clutch and bearing assembly.

Borg-Warner clutches are used extensively in the automobile industry, and in aircraft, gas turbines and air compressors.

Machine Shop Equipment Ltd.

(Sole concessionaires for Stieber Rollkupplung KG, Heidelberg)

The range of precision freewheels offered by this company includes three main kinds which are in metric sizes. Two of these employ the roller and starwheel principle (see Figs. 7a and 7b). The third variety, for high and extra-high idling speeds, employs a clamping element of non-circular cross-section which, when idling is taking place, is thrown out of contact with the inner race and so provides frictionless running.

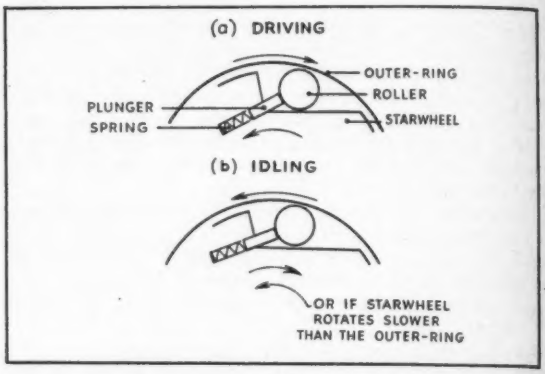


Fig. 7a. NF type freewheels with individually sprung cylindrical clamping rollers, for relatively slow to medium idling speeds.

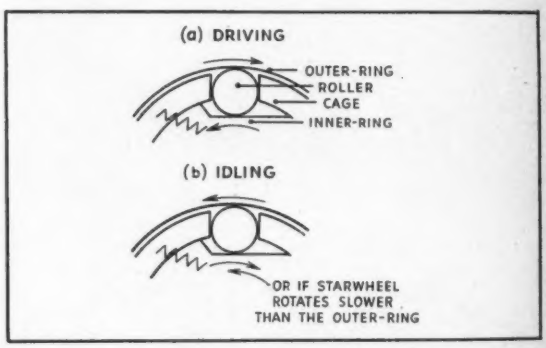


Fig. 7b. KF type freewheels with cage mounted cylindrical clamping rollers, for medium high idling speeds. The idling rollers are accurately guided in a cage, and the spring loading is effected from the cage to the star wheel.

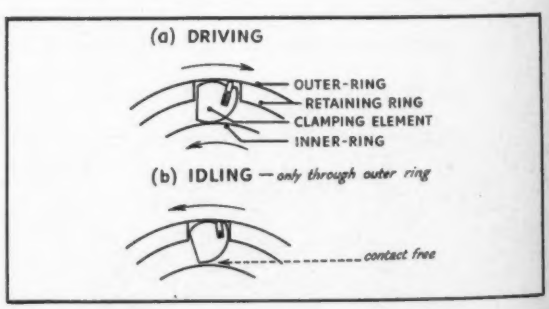
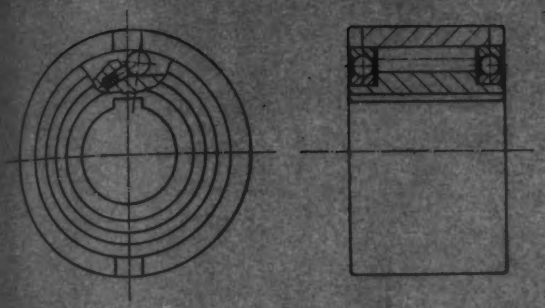


Fig. 7c. CF type freewheels with individually sprung clamping elements, for high and extra high idling speeds. When idling, the clamping elements are thrown out of contact with the inner race. These freewheels are available for specific requirements only.

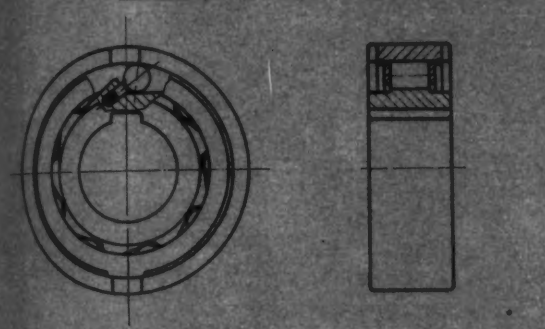


NF Series (three types of application)

Although somewhat resembling a roller bearing, these freewheels are not capable of taking journal loads, and separate bearings for this purpose must be provided. Each roller is held ready to engage by means of two spring-loaded plungers. The rollers and starwheel are secured in the outer race by means of circlips. The NF series is subdivided as follows:

NF Series (Wide Type)

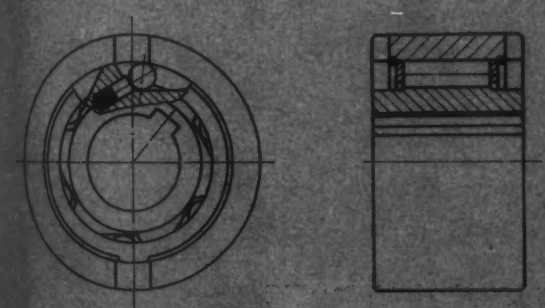
Min. bore size	= 8 mm.	(Max. continuous speed of outer race with pressure lubrication = 3,900 r.p.m.) (Max. permissible continuous torque = 0·6 mkg.)
O.d.	= 37 mm.	
Width	= 20 mm.	
Max. bore size	= 150 mm.	(Max. continuous speed of outer race with pressure lubrication = 500 mm.) (Max. permissible continuous torque = 1,620 mkg.)
O.d.	= 320 mm.	
Width	= 180 mm.	



NFS Series (Narrow Type)

Min. bore size	= 8 mm.	(Max. continuous speed of outer race with pressure lubrication = 3,900 r.p.m.) (Max. permissible continuous torque = 0·5 mkg.)
O.d.	= 35 mm.	
Width	= 13 mm.	
Max. bore size	= 80 mm.	(Max. continuous speed of outer race with pressure lubrication = 800 r.p.m.) (Max. permissible continuous torque = 80 mkg.)
O.d.	= 170 mm.	
Width	= 58 mm.	

The above two types of freewheel are for all three types of duty. Overloads of up to 2½ times the figures quoted can be tolerated for short periods only. Mounting can be in any plane, but correct lubrication is essential.

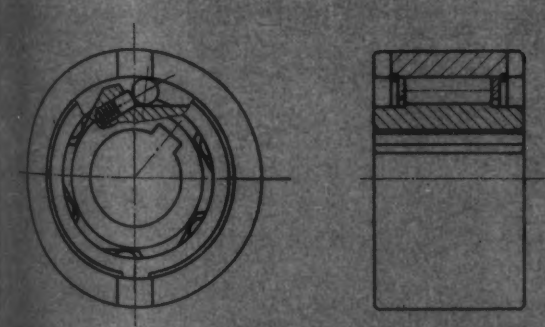


NFL Series

In this series it will be seen that the starwheel is a much closer fit in the outer race. This type is intended for control and indexing only where small and infrequent movements are required.

Min. bore size	= 8 mm.	(Max. continuous speed of outer race with immersion lubrication = 1,000 r.p.m.) (Max. permissible continuous torque = 0·12 mkg.)
O.d.	= 37 mm.	
Width	= 20 mm.	
Max. bore size	= 130 mm.	(Max. continuous speed of outer race with immersion lubrication = 150 r.p.m.) (Max. permissible continuous torque = 915 mkg.)
O.d.	= 300 mm.	
Width	= 180 mm.	

Overloads of up to 2½ times the figures quoted above can be tolerated for short periods only.

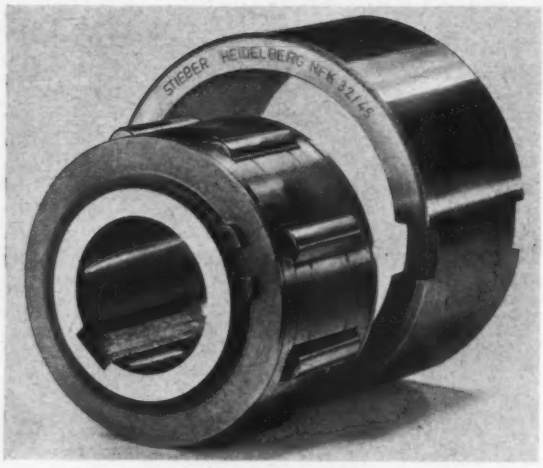


NFR Series

This series is essentially the same as the NF series, with the addition of two ball races. It is suitable for all three functions, and is intended for gearboxes and belt drives, and for incorporation in elastic couplings.

Min. bore size	= 30 mm.	(Max. continuous speed of outer race with pressure lubrication = 1,600 r.p.m.) (Max. permissible continuous torque = 13 mkg.)
O.d.	= 90 mm.	
Width	= 48 mm.	
Max. bore size	= 150 mm.	(Max. continuous speed of outer race with pressure lubrication = 500 r.p.m.) (Max. permissible continuous torque = 1,620 mkg.)
O.d.	= 320 mm.	
Width	= 180 mm.	

Overloads of up to 2½ times the figures quoted above can be tolerated for short periods only.

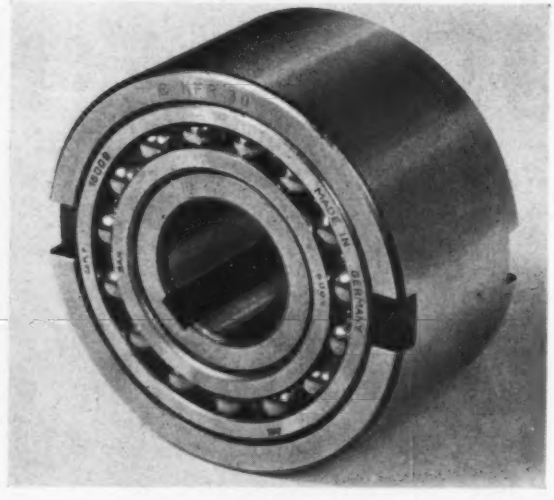


KF Series

This type of freewheel permits higher speeds, but can only be used as an overrunning clutch or return lock. The rollers are confined in a cage around the starwheel by two spiral springs together with retaining rings and circlips. This construction allows a high-speed drive to be coupled to either the inner or the outer ring. Separate bearings must be provided.

Min. bore size	= 20 mm.	(Max. continuous speed of
O.d.	= 62 mm.	outer race with immersion
Width	= 36 mm.	lubrication = 3,200 r.p.m.)
		(Max. permissible continuous torque = 5 mkg.)
Max. bore size	= 130 mm.	(Max. continuous speed of
O.d.	= 300 mm.	outer race with immersion
Width	= 180 mm.	lubrication = 1,400 r.p.m.)
		(Max. permissible continuous torque = 915 mkg.)

Overloads of up to 2½ times the figures quoted above can be tolerated for short periods only.

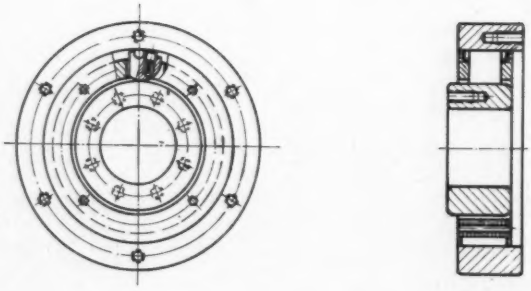


KFR Series

This is essentially the KF series provided with integral ball races, and is intended for the same types of application, namely for use as an overrunning clutch or return lock. The faces of the outer ring are provided with tapped holes for flange mounting.

Min. bore size	= 25 mm.	(Max. continuous speed of
O.d.	= 80 mm.	outer race with immersion
Width	= 63 mm.	lubrication = 3,400 r.p.m.)
		(Max. permissible continuous torque = 6·8 mkg.)
Max. bore size	= 130 mm.	(Max. continuous speed of
O.d.	= 300 mm.	outer race with immersion
Width	= 228 mm.	lubrication = 1,400 r.p.m.)
		(Max. permissible continuous torque = 915 mkg.)

Overloads of up to 2½ times the figures quoted above can be tolerated for short periods only.



CF Series

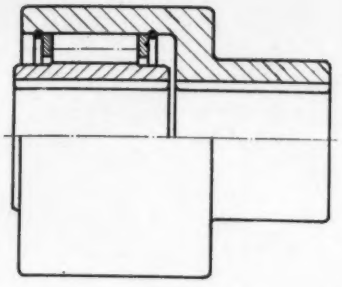
These contact-free type freewheels, which include the CFS (narrow) and CF (wide) types, are designed for use at high and extra high speeds. They become contact-free at around 200-300 r.p.m., the clamping elements lifting under the influence of centrifugal force so that the inner ring rotates freely out of contact with the outer ring. Such freewheels can be used with advantage as return locks or overrunning clutches, as for example in starter motors when there is a slow increase in speed from a standstill. Reliable operation is assured without lubrication, even with continuous idling speeds of over 10,000 r.p.m. They are recommended for use in fireproof motors.

CF Series (Wide Type)

Min. bore size	= 52 mm.	Width of inner race = 50 mm.
O.d.	= 180 mm.	Width of outer race = 45 mm.
Max. bore size	= 122 mm.	Width of inner race = 250 mm.
O.d.	= 250 mm.	Width of outer race = 45 mm.

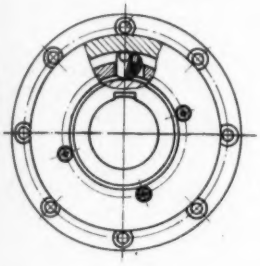
CFS Series (Narrow Type)

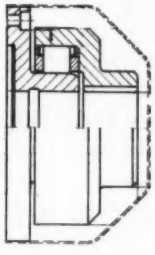
Min. bore size	= 21 mm.	Width of inner race = 35 mm.
O.d.	= 100 mm.	Width of outer race = 30 mm.
Max. bore size	= 71 mm.	Width of inner race = 35 mm.
O.d.	= 150 mm.	Width of outer race = 30 mm.



NA/NF Shaft Coupling Units

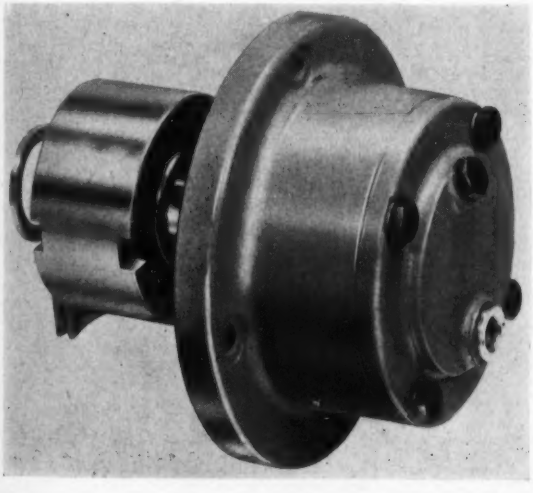
These are designed to incorporate either the NF Series (Wide) or KF freewheels. The outer ring is necked to provide a coupling for two shaft ends.





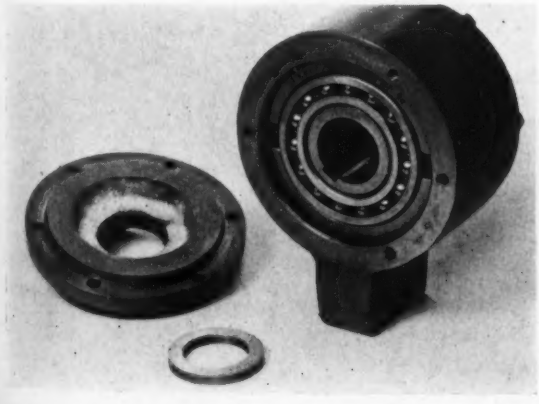
RS/CF Series

These are flanged shaft coupling units, incorporating the CF type freewheel. They are intended for starter motor applications.



RS/NF Series

This is another type of standard fitment designed for flange mounting of the standard NF or KF types of freewheel.

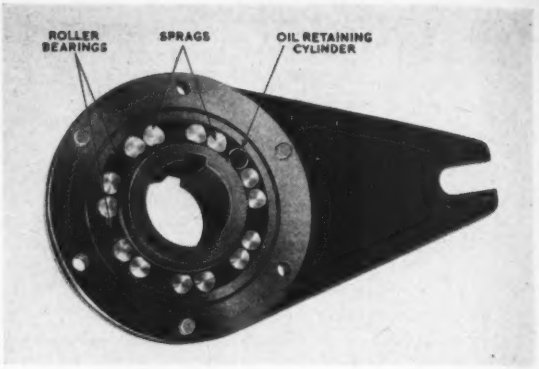


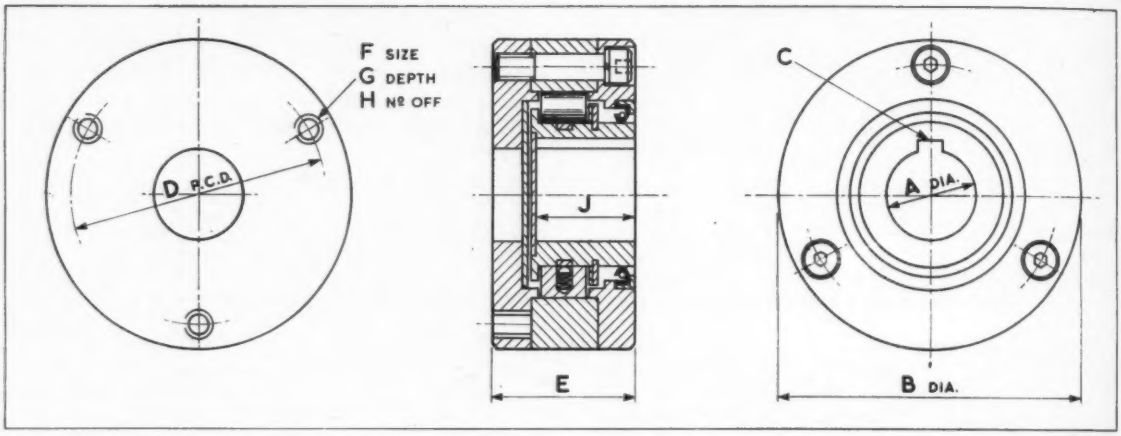
RS/NFR Series

A further type of standard fitting, designed to incorporate the NFR freewheel with integral ball races.

BACKLASH—This depends to some extent on the type of lubrication, whether by grease, immersion lubrication or pressure lubrication. At the outside diameter of the NF and NFL types, backlash is stated to be of the order of 0·2 mm. with grease lubrication, and 0·1 mm. when oil is used. This linear method of giving backlash is explained by the fact that the spring loading of the rollers is different for each increment of size. The manufacturers state that the angle through which the outer ring can still be turned on when taking the torque amounts to about 0·4-0·7°.

OVERRUNNING—The speeds given are for when the outer race is overrunning. When the inner race is to overrun the figures given must be diminished by between 10 and 50 per cent, on account of the extra friction generated between the rollers and the outer race by centrifugal action.





A Stock	A Max.	B	C (* two at 90°)	D	E	F BS fine	G	H	J	Torque (lb. in.)	Maximum r.p.m.	Maximum h.p.
$\frac{1}{2}$	$\frac{11}{16}$	$3\frac{1}{4}$	$\frac{1}{8}\times\frac{1}{8}$	$2\frac{5}{8}$	$1\frac{9}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	3	$1\frac{3}{32}$	148	6,000	14
$\frac{3}{4}$	$\frac{15}{16}$	$3\frac{1}{2}$	$\frac{5}{16}\times\frac{3}{16}$	$2\frac{7}{8}$	$1\frac{5}{8}$	$\frac{1}{4}$	$\frac{13}{32}$	3	$1\frac{1}{8}$	500	6,000	45
1	$1\frac{1}{16}$	$3\frac{5}{8}$	$\frac{1}{4}\times\frac{1}{4}$	3	$1\frac{5}{8}$	$\frac{1}{4}$	$\frac{13}{32}$	3	$1\frac{1}{8}$	1,185	6,000	110
$1\frac{1}{8}$	$1\frac{3}{16}$	$3\frac{3}{4}$	$\frac{5}{16}\times\frac{1}{4}$	$3\frac{1}{8}$	$1\frac{3}{4}$	$\frac{5}{16}$	$\frac{15}{32}$	3	$1\frac{3}{16}$	1,690	6,000	160
$1\frac{1}{4}$	$1\frac{5}{16}$	4	$\frac{5}{16}\times\frac{1}{4}$*	$3\frac{3}{8}$	$1\frac{3}{4}$	$\frac{5}{16}$	$\frac{15}{32}$	4	$1\frac{3}{16}$	2,315	6,000	220
$1\frac{3}{8}$	$1\frac{7}{16}$	$4\frac{1}{4}$	$\frac{3}{8}\times\frac{1}{4}$*	$3\frac{5}{8}$	$1\frac{3}{4}$	$\frac{5}{16}$	$\frac{15}{32}$	4	$1\frac{3}{16}$	3,070	6,000	290
$1\frac{1}{2}$	$1\frac{9}{16}$	$4\frac{3}{4}$	$\frac{3}{8}\times\frac{1}{4}$*	4	$1\frac{3}{4}$	$\frac{3}{8}$	$\frac{15}{32}$	4	$1\frac{3}{16}$	4,000	6,000	380

Padomatic Ltd

The Padovatic freewheel, unlike most other types, incorporates roller bearings between the sprags and is therefore able to take journal loads. This makes it a likely choice when the freewheel or backstop must be housed in a confined space where there is no room for journal bearings on each side. The inner and outer races are somewhat similar to those used for roller bearings. The two races are maintained concentric about a common axis by the insertion of the rollers, the intervening spaces between the rollers being filled by a patent type of sprag which in cross-section approximates to a heart shape.

In the freely running direction the differential movement between the inner and outer races and the heart-shaped sprags results in a reduction in dimension across the contact surface of the inner and outer parts of each sprag; but when driving, the differential movement between the inner race and the outer race immediately results in an increase in dimension between the inner and outer lobe of the heart-shaped sprags, so that a jamming action occurs between the sprags and the races. According to the arrangement adopted, the outer or inner race may be the driving member.

To prevent any possibility of the sprag departing from the intimate contact of the two surfaces, a small piston actuated by a spring is let into the sprag to maintain contact. To prevent undue rubbing of the inner race, the piston head is allowed to bear upon a floating ring let into a recess in the inner race, or the outer, according to which is the driving member. The total diameter over this ring is less than the diameter of the inner race, so that the roller bearings do not contact the ring. For high speeds, one of the roller bearings is replaced by a hollow cylinder having a saw cut through the wall. This cylinder effectively lubricates the inner race surface, since the lubrication would normally be centrifuged to the outer race, leaving the inner race dry and prone to failure. The races are made to individual order, in either metric or inch sizes.

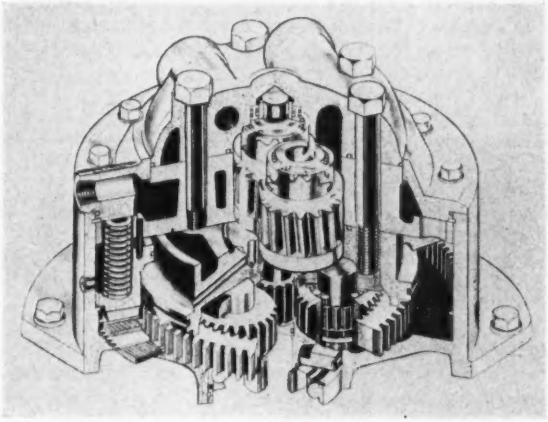
(To be concluded in the July issue.)

NEW IDEAS IN DESIGN

Outstanding products in current manufacture and awaiting development in the U.K.

Hydraulic Gear-head Motors

A NEW line of planetary drive gear-head motors powered entirely by hydraulics has been introduced by Gearmatic Co. Ltd., of Newton, British Columbia, Canada. Called Roto-Versal, the new in-line units are available in three sizes and six reduction ratios, and can be supplied with the same speed in both rotations, or with a high-speed reverse which produces 0-5¼ times forward speed. The new unit features a metering valve which operates in both rotations and provides exceptionally smooth stops and starts. An automatic brake is actuated by pressure changes, and any loss of pressure immediately sets the brake to prevent any load-taking charge. Possible applications for Roto-Versal are as the primary drive units for hoisting, conveying and winching equipment.



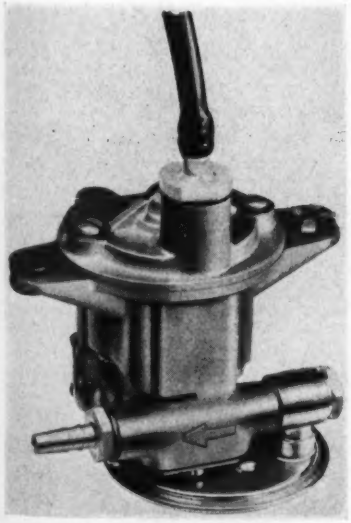
Electric Fuel Pump runs in Petrol

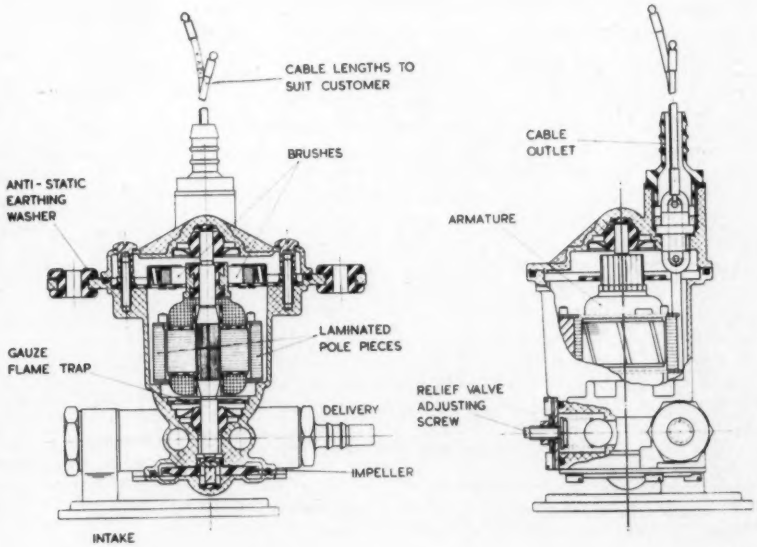
THE prevention of vapour locking troubles in automobile fuel systems is a problem which has become prominent with the advent of high volatility fuels, coupled with the growing use of motor vehicles in hot climates. Vapour locking is particularly troublesome on the suction side of a fuel system. It follows, therefore, that a most effective counter-measure is to locate a pump below the surface level of the fuel. When located thus, no vacuum can occur on the intake side of the pump which, being gravity fed with liquid fuel, can maintain its rated pressure on the delivery side. This is the working principle of the new Lucas electric fuel pump, Model 2FP.

The pump is a composite unit containing, within a single body and between two end covers, a permanent magnet field electric motor and a cumulative-type centrifugal pump. The body and end covers are of zinc pressure-die-cast construction, while an integral mounting foot provides two-hole fixing of the unit through two petrol-proof rubber grommets. An earthing washer on one of the fixing bolts provides an earthing path from the pump unit to its mounting bracket, thus preventing the build up of electrostatic charges on the unit. The pump is fully sealed and suitable for mounting either in the fuel tank or adjacent to it.

The insulated-return motor has a high-energy permanent magnet field system for simplicity, reliability and robust construction. Two p.v.c.-covered supply cables from a terminal moulding pass through a sealed outlet and nylon union. When the unit is mounted inside the fuel tank, the cables pass through high-grade petrol-proof plastics tubing, and are brought out of the tank through a Hycar rubber gland. In operation, the whole of the interior of the unit, including the commutator and brushgear of the motor, is flooded with fuel, but since there is no projecting shaft it is claimed that no troubles of the kind associated with rubbing seals can arise.

The pump is claimed to be safe even if it were to become filled with a suitably combustible mixture of fuel vapour and air in an empty tank.





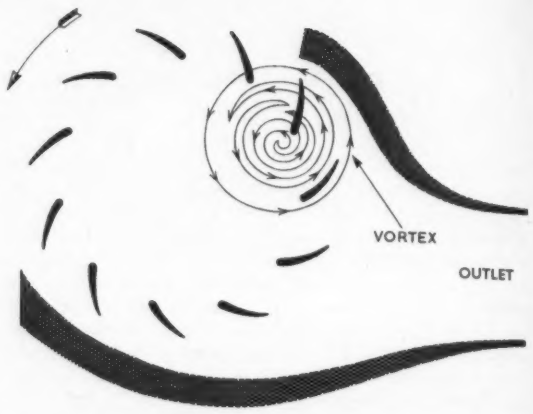
Revolutionary New Fan

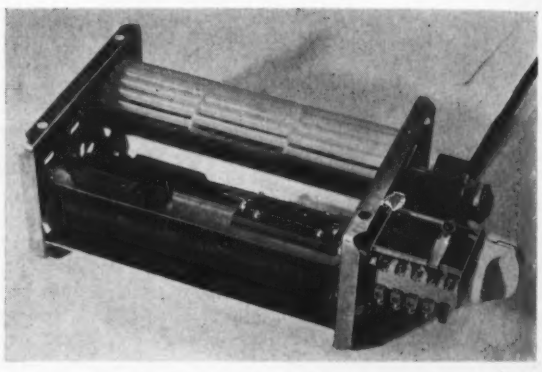
SMALL fans used for engine cooling and room ventilation, and more recently incorporated in room heaters, tend to be both inefficient and noisy, since they work in a "stall régime". The air flow produced tends to be turbulent and therefore soon loses its heat locally, or can cause secondary circulation of cold air.

The Tangential Flow fan, to be produced in the U.K. by Solartron Ltd. (a member of the Cleveland Group of Companies), operates on an entirely new principle developed during the past ten years in Germany by Nicholas Laing. This new fan is claimed to be far more efficient.

As is shown in the accompanying photograph and diagrams, the rotor is a bladed cylindrical unit driven by a motor from one end. Inside the rotor a long cylindrical vortex is set up which is stabilised by a vortex former, so that the centre of the vortex is a very short distance from the inner edges of the rotor blades. This causes the vortex to rotate with high angular velocity. The outer "shell" of the vortex moves with high speed and couples to the input and output airstreams, which are pulled past the blades of the fan with higher velocity than the peripheral speed of the blades themselves. This principle, with its double traversal of the blades, is claimed to give more throughput per unit frontal area than any other type of fan. It also produces a high air velocity with a comparatively low peripheral blade speed. The noise/power output of a fan varies approximately with the 5·5th power of the blade speed. This explains the notable noise reduction in the tangential fan.

The range to be manufactured by Solartron Ltd. will include modular versions incorporating a heater unit of unique design. The high velocity of throughput enables a powerful heater to be used in a small fan unit without increasing the temperature of the output air to an uncomfortable level. The heater element is formed as a helix of edgewise-wound ribbon, and is supported on an insulating cradle in such a way that it cannot collapse at any working or emergency temperature. An adjustable safety cut-out is provided.





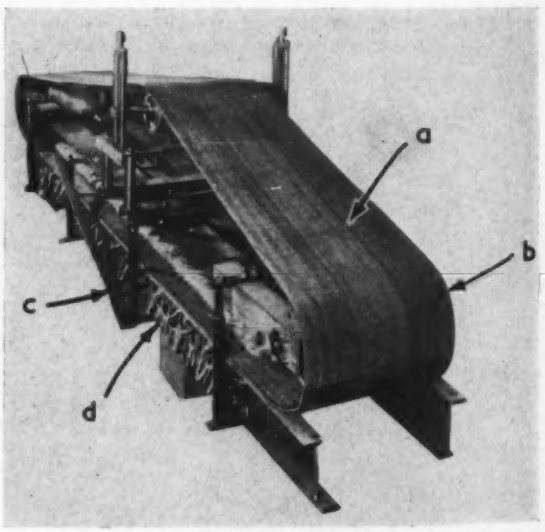
The range should be of considerable interest to manufacturers of room heating and cooling equipment, motor cars, cinema projectors (for cooling the lamp) and electronic apparatus.

Linear Motors for Conveyors

SEVERAL types of conveyor suffer from the disadvantage that the force is applied to the belt over a comparatively small area, so that the force per unit area is large. This is liable to stretch the belt and, if this occurs, slipping may result so that some of the drive is lost. Slipping causes excessive wear, and introduces the possibility of fire. Slipping may also occur owing to changes in operating conditions, such as wetting of the belt or excessive load, and to counteract this tendency the tension is often increased to such an extent that the thickness and cost of the belt required to withstand this tension are excessive.

Recent developments in linear induction motors have suggested that they might be used with advantage as conveyor drives. In this case the belt itself is made from conducting material, and constitutes the "rotor" of the motor. An experimental woven belt conveyor* developed along these lines on a subscription from a research department of the National Coal Board, at Manchester University, is shown in the accompanying photograph. The manufacturer was A.E.I. (Manchester) Ltd., Trafford Park, while N. Greening & Sons Ltd., of Warrington, manufactured the belt as an almost standard item.

The force is imparted to the belt uniformly over a large



Experimental linear motor driving a woven wire belt—*a*, centre section of belt composed of copper rods and stainless-steel wire; *b*, end sections of belt composed entirely of copper wire; *c*, end connections of upper stator winding; and *d*, end connections of lower stator winding.

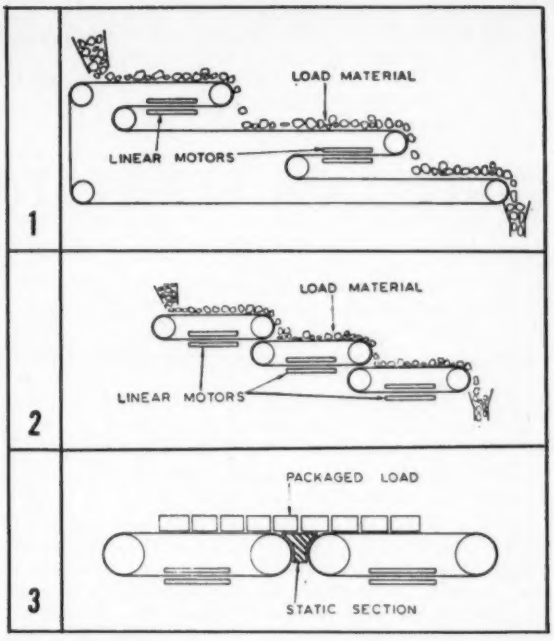
* *Potential users of this unit should write to Dr. E. R. Laithwaite, Electrical Engineering Laboratories, Manchester University.*

area by the linear stator without rubbing contact, and the drive is therefore independent of the coefficient of friction between the belt and any rollers around which it may pass. The drive is applied over a straight length of belt between the rollers, the latter being now merely a means of guiding the belt.

Several methods of applying linear motors to drive belts are shown. Only systems in which a linear stator is placed on each side of the belt can be made reasonably efficient, unless the belt itself contains a considerable amount of iron, which is not usually economical.

Two types of belt have been tested under laboratory conditions. The first consisted of woven copper wire mesh, and the second of a series of aluminium plates connected to a chain along each side of the track.

Difficulty has been encountered in obtaining high efficiency on slow-speed belts (10 ft./sec. or less) from 50 c/s supply, but it has been found that high efficiency and power handling capacity are possible if a low-frequency a.c. supply is available. For example, a woven belt 36 in. wide is capable of delivering 10 h.p. per foot of stator length at 61 per cent overall efficiency at a speed of 7·5 ft./sec. from a supply frequency of 5 c/s. A plate belt of similar dimensions and speed would give 15 h.p. per foot at 75 per cent efficiency.



(*Right*) Various conveyor systems using linear-motor drives —*1*, continuous-belt system; 2, short-belt system; and 3, static-section system.

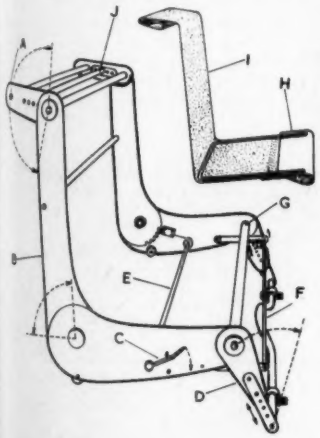
A New Concept in Car Seat Design

THE majority of cars are fitted with seats having batteries of coil springs held together by spring frames and wire mesh. A heavy passenger causes the springs to close up, and leaves nothing in hand for road shocks.

The Searle car seat represents an interesting departure from the conventional design, since, in addition to providing marked improvement in comfort for the passenger, even over pot-holed roads, it would appear to be an essentially simpler seat to manufacture. Unlike the conventional type of seat, it is almost infinitely adjustable to suit the passenger, and can, at the touch of a lever at the side, be tilted backwards to enable him to take a nap.

The accompanying perspective line drawing and photograph illustrate the type of construction used in a prototype, but the inventor emphasises that manufacturers might not necessarily employ side plates of the type shown, but might prefer to use some other form of construction. The main feature of the seat is the patented built-in frame *H*. This is bent round tube *G*, a C-shaped tube being welded to its upper surface to give seat depth. The frame rests on

a sheet of neoprene-coated terylene looped at both ends. This base material is claimed to adapt itself instantly to any contour imposed thereon, stability being ensured by the weight of the passenger bringing the squab into tension.



A Full-width headrest.
B Rising and falling squab.
B Squab locking lever.
D Adjustable legs.
E Squab locking control bar.
F Backwards and forwards movement control bar.
G Leg support tube.
H Seat frame (looped to slide over G).
I Neoprene-coated Terylene foundation.
J Upholstery adjuster bar.

A full-width headrest remains set at any angle by slight pressure, this serving also as an upholstery adjuster. Further adjustment for the upholstery is provided by a tensioning bar *J*, which is internally fitted with spring-loaded pegs. This adjusts the general height of the seat base and at the same time affords slight alteration of the squab angle. Adjustable legs at the front are also provided.

Further advantages claimed are that wear to clothing caused by rubbing against the upholstery is eliminated, since the seat fabric is in one piece. There is an absence of spring creak, and rear passengers are provided with an additional 7 in. of leg room.

The version described is a *de luxe* model, but less expensive types, without headrest and rising and falling squab, could be manufactured more cheaply. World patents are pending. Manufacturers interested in this seat are asked to get in touch with the inventor, Mr. L. Searle, Green Gates, Cross Oak Road, Berkhamsted, Herts.

CASTING OR FABRICATION?

The choice between a casting and a welded fabrication may perplex even an experienced designer—the following extracts from a recent research programme compare the relative merits of these techniques

STEEL castings and welded fabrications are competitive materials often used in industry; a recent research programme was undertaken to provide (a) information on the design of steel castings and welded sections, and (b) a comparison of the properties of these sections. These studies will help the designer to become more familiar with the characteristics of these two methods of making stress carrying parts of engineering structures.

The L and box section test specimens employed in the research were manufactured by methods which are considered standard commercial practice for each process. The wrought and cast steels used were carbon steels normally specified. The tensile strengths of these steels were not the same, but they were generally representative of each of the particular manufacturing processes.

It might have been desirable to have these two materials of comparable tensile strengths, but the essential requirement was that the study and comparison of these materials should be based on normal commercial welding and casting techniques, as specified for similar service applications.

Good design requires that the junction of sections be filleted. Four different corner designs were tested as steel castings (see Fig. 1), and three as welded structures (see Fig. 2), only two of the latter being the same as the casting designs. The corners represented a range of design practices; those that are normal for casting designs are not common for welded designs.

The weld designs *E* and *G* (see Fig. 2) are preferable for both static and dynamic loading, full strength being obtainable for all loadings. Weld design *F*, the single fillet welded joint, is, however, used in product design, because the structure can be welded from only one side, the use of this design being on the basis of low cost construction. It should not be used when tension resulting from bending is concentrated at the root of the weld, nor when the joint is subject to fatigue or impact loading. However, this joint is sometimes used in such service because welding is only possible from one side. Many parts in dynamic loading have, however, been made using the single fillet welded joint of type *F*.

The box design castings were produced with all corners alike (see Fig. 3). This was not possible in the case of the welded box designs, which were made by producing type *E* or type *G* corners, and then welding the two L plates together with type *F* design. The test loads were applied at the type *F* corner so as to test type *E* and *G* corners. Specimens were prepared by both machine and hand welding.

Failure of an engineering part of this type occurs either by fracturing or by yielding. A comparison of section junctions of welds and castings was made to determine the loads which would produce yielding of the structure, both the L and box sections being tested in tension. Wire strain gauges were mounted so that they spanned the point of estimated maximum stress. The load which caused an offset of 0·2 per cent on the load-strain curve was defined as the yield load in lb. Yield load rather than yield stress was determined, because of the uncertainty of defining stress precisely from either strain measurements or theoretical calculations based on load, geometry, and stress-strain laws for the particular material.

Each of the five different corner designs has a different stress concentration factor, which is defined as the ratio of the observed stress (as determined experimentally from strain measurements) to the nominal (calculated) stress. However, it is not always possible or practical in planning a design to make the part and measure the yield load before final selection of the material and method of manufacture, as has been done in these studies. Nevertheless, it is necessary to have some means of computing the limiting load and determining the stress concentration factors. Another method of arriving at a value of stress concentration factor is by photoelasticity. In this case, the stress concentration factor is the ratio of the photoelastic stress divided by the nominal stress. The stress concentration factors computed

Table 1. Stress concentration factors for the L and box designs

Corner Design		Process	Factors determined by: Photo-elasticity	Strain Measurement
A	L design (see Fig. 1)	Casting	1·21	1·17
B		Casting	1·23	1·22
C		Casting	1·36	1·33
D		Casting	1·58	—
E	L design (see Fig. 2)	Weldment	1·21	1·64
G		Weldment	1·23	1·92
F		Weldment	1·52	—
A	Box design (see Fig. 1)	Casting	1·21	1·37
B		Casting	1·23	—
C		Casting	1·36	1·40
D		Casting	1·58	—
E	Box design (see Fig. 2)	Weldment	1·21	2·13
G		Weldment	1·23	2·10
F		Weldment	1·52	—

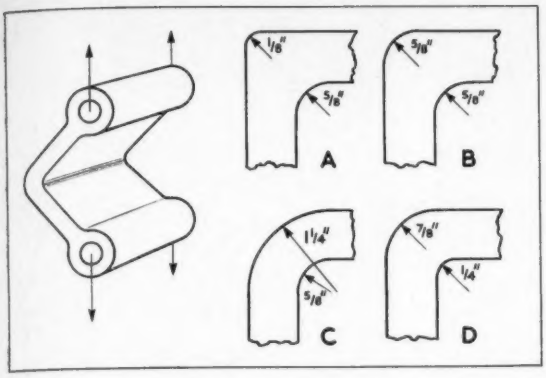


Fig. 1. Corner-type designs for cast steel L specimens, one of which is shown on the left.

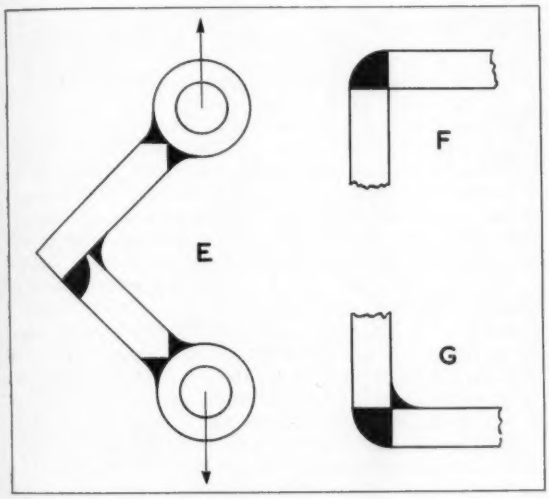


Fig. 2. Diagram illustrating the fabrication techniques employed in producing corner joints.

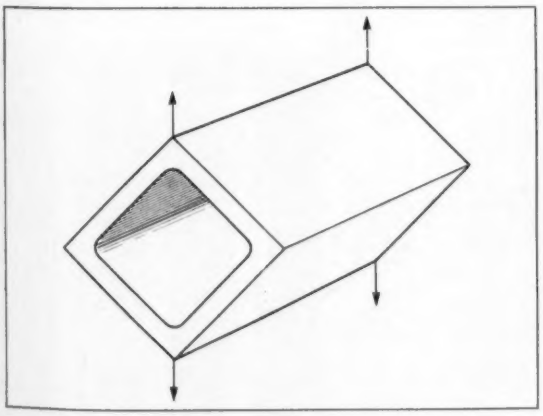


Fig. 3. Sketch of the box design specimen in cast steel, showing the points where load was applied.

from the experimentally measured strains and from photoelastic stress should agree, and Table 1 gives the stress concentration factors for the various corner designs as determined by these two methods.

The data in Table 1 are significant. Many designers rely on photoelastic measurements, but the photoelastic specimens are idealised in that they duplicate the drawing exactly and do not have any manufacturing imperfections of surface or section. The loading tests and strain measurements, on the other hand, are made on actual parts having deviations from the ideal drawing, and surface imperfections. Therefore, the stress concentration factor determined from photoelastic measurements is the ideal factor, while that which is obtained from strain gauge measurements is more nearly the actual stress concentration factor.

The two stress concentration factors agree remarkably well for the steel castings, but the photoelastic method greatly underestimates the strain measurement determined factor for the welds. The major reason for this deviation is the inevitable departure of the fillet geometry from that shown by the idealised drawings.

There is naturally considerable interest by material engineers and designers in fatigue tests, particularly tests on parts distinct from pure laboratory fatigue tests, because fatigue accounts for more service failures than any other single type of failure. There was a time when the only fatigue test figure of interest was the endurance limit, i.e. the highest alternating stress which could be applied and still not break the specimen. Recently, there has been interest in limited fatigue life, since machines and equipment are not always designed to last indefinitely, and basing a design on a stress which permits infinite life may be unnecessarily restrictive. Many designers are interested in the results of limited life fatigue tests, which are merely a thorough study of the sloping portion of the familiar S-N curve, and information has been presented on the S-N curves for cast and welded box sections, and on the percentage of failure of both cast and welded L and box sections tested under different loadings.

The steel castings were always equivalent to the welded sections, and generally showed marked superiority when judged by static load test at yielding, or by fatigue life at a given load. The strength of the cast steel was higher than that of the wrought steel; however, this is the normal condition of commercial steel castings and welds.

It has been shown by these studies that although the difference in load at the yield point in the static test is explained by the difference in the mechanical properties of the steels, the variations in fatigue results were too great to be explained on a similar basis.

Attempts were then made to explain the fatigue results by differences in specimen dimensions, particularly the width of the joint. Although rather serious deviations from the planned designs were found, no good correlation with the fatigue results was observed, so it is concluded that any effects resulting from variations of dimensions are covered up by the effects of other factors.

The main reasons for the superiority of the steel castings in fatigue service were the superior surfaces of the castings, and the much lower stress concentration because of the well-radiused fillets and smooth blending at the point where the fillet joined the junctioning member.

The poor fatigue life values for the welded sections were the result of the formation of flat fillets during welding, which permitted stress concentration points. If all of the fillets were machined and true radiused fillets produced, then excellent results with welded joints could be obtained. However, this operation is not economically feasible if welded sections are to compete in cost with castings.

Abstracted from A.S.M.E. paper 60-SA-2, "Studies of the Design of Steel Castings and Steel Weldments as related to Methods of their Manufacture".

GLASS IN MODERN ENGINEERING

Few engineers would, on first consideration, include glass as one of the vital materials for present-day designs. However, this article shows that glass has become an indispensable factor in modern engineering

by the late GEORGE W. McARD, A.M.I.Mech.E.

IN the early stages of its production glass has to pass through similar processes to steel, in that it is obtained by melting under intense heat a blending of silica with an alkali, or alkaline earth such as lime, and other constituents. Where these constituents are of mineral origin, care must be exercised in their selection and treatment to eliminate impurities which might have a serious influence on the quality of the finished product.

The intensive research work undertaken by large glass firms has focused attention on the vast possibilities for this material in almost every industry. Given below is a summarised list of the main types of glass:

FLAT DRAWN SHEET GLASS—Made in various thicknesses and referred to in the trade according to its weight, i.e. 24, 26 or 32 oz. per sq. ft. The surfaces, being pre-finished and not perfectly parallel, give a certain amount of distortion in vision.

POLISHED PLATE GLASS—Standard thicknesses range from $\frac{1}{4}$ to $1\frac{1}{4}$ in. Since both surfaces are ground and polished, undistorted vision and reflection are ensured.

WIRED GLASS—Two types of wired glass $\frac{1}{4}$ in. thick are available: (a) wired cast (wired mesh, square or hexagonal) —translucent; (b) polished wired (wire mesh, square or hexagonal)—transparent. (Wired cast glasses have a rough cast finish, but the polished wire types have both surfaces ground and polished.)

PRISMATIC GLASS—When light passes through ordinary flat window glass, the rays emerging travel in a direction parallel to that at which they fall on the glass. This characteristic can sometimes be a drawback, because where windows are overshadowed by adjacent structures, the only direct light from the sky reaches the windows from a steep angle; also, in cases where the windows are open to the sky, glare can be very troublesome. In the former instance, it is necessary to use artificial lighting continuously in the area remote from the windows, and in the latter, blinds or other artificial means of cutting down the light must be utilised, with the result that areas remote from the windows are darkened.

For a long time it has been known that the direction of a beam of light can be changed by passing it through a prism or triangular wedge of glass. This principle has been put to practical use in prismatic glass, which has been designed scientifically to refract rays of light passing through it. Prismatic glass is a rolled flat glass having, on one face, parallel wedge-shaped ridges; the other face being smooth. It is manufactured in three angles (see Fig. 1): No. 1, to be used where the required angle of bend does not exceed 35°; No. 2 for an angle of 35 to 45°; and No. 3 when the angle exceeds 45°. Where the angle of incidence exceeds 60°, the percentage of light reflected from the smooth surface increases to such an extent that prismatic glass ceases to serve a useful purpose.

This form of glazing can be usefully employed in many situations, but it has not hitherto been used to the best advantage. Glare due to dazzling sunlight shining on polished surfaces below, e.g. machines, desks, etc., can be minimised by skilful use of prismatic glass, the sun's rays being deflected from the angle of glare.

OPAQUE GLASSES—may be obtained in a variety of designs, most of which are intended to secure some degree of privacy. In the two designs known as "hammerstripe" and "feathered" (see Fig. 2), the brilliance of the lighting effect is very marked. Another form of opaque glass, technically termed "one-way vision glazing", is that fitted in ambulances and certain public service departments (e.g. clinics). The material generally used is a neutral-tinted plate

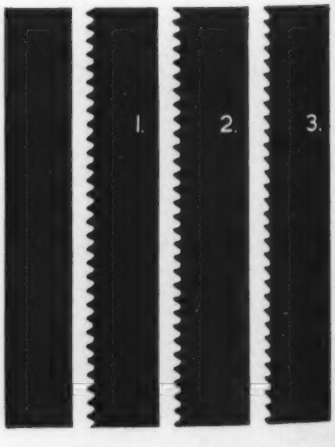


Fig. 1. Showing the three angles of prismatic glass (Pilkington Bros.).

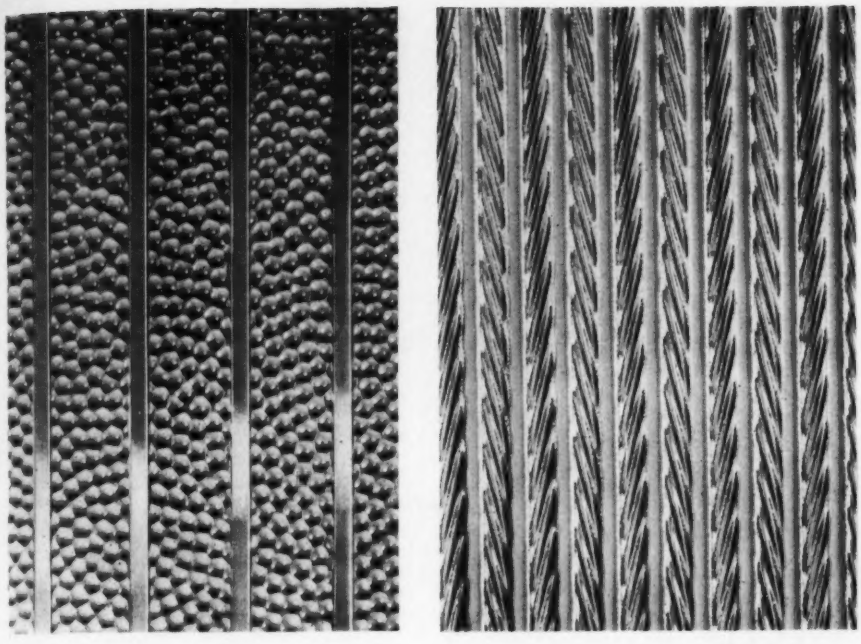


Fig. 2. Opaque glasses—(*left*) hammerstripe; (*right*) feathered (Pilkington Bros.).

glass which from the outside resembles a black mirror. The actual effect produced depends solely on the relative intensity of the lighting on the two sides of the glass—in daylight the ambulance occupants can see out quite distinctly, but the public cannot observe the occupants. When electric light is switched on at night in the ambulance, conditions are reversed.

Many glasses are coloured by the addition of small quantities of metallic oxides or their equivalent. Special grades of glass are available of which the manufacture is carefully standardised to meet rigid optical standards. Among these are the lenses made to transmit a powerful beam of light, e.g. traffic signals for fast-moving units on rail or road. Other glasses are designed to afford visibility while reducing the transmission of heat and glare, as in the goggles provided for welders, furnace operators and similar, and also sun glasses.

TOUGHENED GLASS—is obtained by carefully controlled heating and cooling with the object of setting up differential tensile stresses at the centre of the material cross-section, and compressive stresses at the two outer surfaces. By this means the outer surfaces are thus better able to resist tensile stress set up by a shock load. The advantage which derives from this toughening process is definitely in evidence when fracture does take place, failure in the unit releasing the strain by break-up of the stress arrangement, and the energy being expended in the shattering of the glass into minute fragments.

FLOAT GLASS—is a modern high-quality glass which combines every good feature that is obtained with first-grade plate glass, plus some other advantages in finish and manufacture. Both surfaces will be found perfectly true and parallel without grinding, and each has a brilliant fire finish free of any defects. In its production it commences at the furnace outlets and flows as a continuous ribbon of molten glass on to the surface of a bath of liquid metal, which is maintained at a controlled temperature. From there it issues as a dead-flat ribbon free from distortion, having an extremely good mirror-like finish on both surfaces. During the last stage of its journey through the float bath its temperature falls sufficiently to allow it to be transferred to the annealing lehr or oven, from which it rolls to the cutting table as a finished glass ribbon 100 in. wide (see Fig. 3).

INFRA-RED TRANSMISSION—Ordinary glazing has the property of being relatively transparent to short-wave infra-red rays, but opaque to the longer wave lengths. This

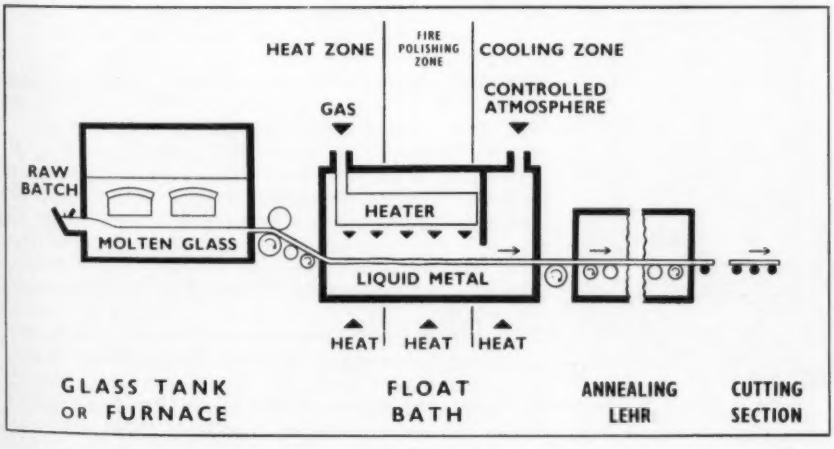


Fig. 3. Flow diagram of the various steps in the production of float glass (Pilkington Bros.).

is the reason why horticultural glass houses accumulate heat from the sun's rays—radiation of short wave length from the sun is transmitted by the glass, and is absorbed by plants, benches, walls, etc., inside the hothouse; these become hot and, in turn, re-radiate heat of longer wave length which cannot pass through the glass, and which is reflected back to the interior. The integral transmission of solar radiant heat through ¼ in. polished plate is 77 per cent.

TRANSMISSION OF LIGHT THROUGH GLASS—The actinic value of lighting suffers by transmission through glass. In the following table the transmission of light is quoted as a percentage value of the amount of light which would pass through the same opening if it were left unglazed.

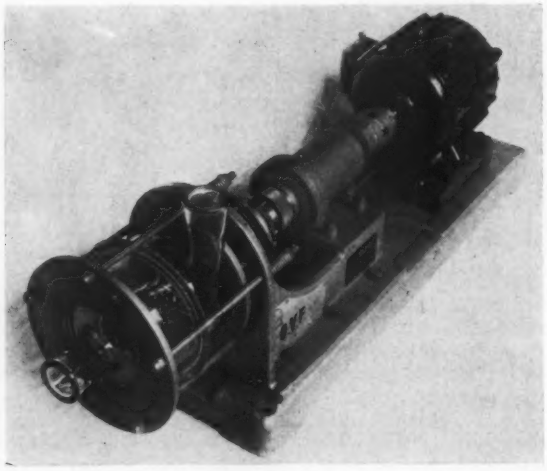


Fig. 4. Glass pump, for use with corrosive fluids (Q.V.F. Ltd.).

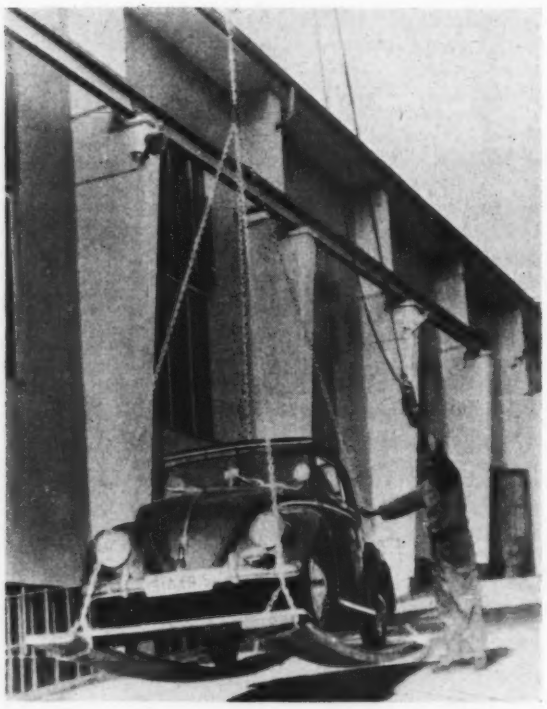


Fig. 5. Glass chain in use for car maintenance (Kettenwerke Schlieper, West Germany).

	Direct light (per cent)	Diffused light (per cent)
Transparent Single Glazing		
Sheet and ¼ in. polished plate	90	85
¼ in. „ „	86	81
¼ in. „ wired	83	80
Translucent Single Glazing		
⅛ in. rolled and ¼ in. rough cast	—	80-85
¼ in. wired cast	—	75
Prismatic	—	65
Figured glasses (varying according to pattern)		70 to 85
The values for Shiplyte and Coralyte are, respectively,		83 and 75

TRANSMISSION OF SOUND—The elimination of the transmission of sound through windows, depends on the care with which all possible leakages are sealed up—also, to some extent, on the thickness of the glass. Where there are double windows, better sound insulation, partly due to the increased mass of the two windows, but largely because of the air space imprisoned by the glasses. Whereas ¼ in. provides the optimum thermal insulation in vertical windows, for sound insulation 2 in. is the minimum recommended for high frequencies, with 4 in. for low and medium frequencies. An increase in thickness to a maximum of 10 in. where possible gives definite benefit.

For double windows, the approximate sound reduction values in the range 100 to 3,200 c/s are as follows:

Type of Window	Sound reduction value (in decibels)
Opening lights (closed)	
24-32 oz. sheet glass, 4 in. space	22
24-32 oz. sheet glass, 8 in. space	24
¼ in. polished plate, 4 in. space	22
¼ in. polished plate, 8 in. space	24
Fixed lights, or opening lights properly fitting on to airtight weather strips or special cushion seals, plus absorbent material on sides of air space	
24-32 oz. sheet glass, 4 in. space	34
24-32 oz. sheet glass, 8 in. space	40
¼ in. polished plate, 4 in. space	38
¼ in. polished plate, 8 in. space	44

MECHANICAL STRENGTH—Glass does not lend itself to precise stress calculations in the same way as the various metals used in engineering equipment, no doubt due to its extremely brittle character and the fact that glass never breaks until the critical tensile strength is developed at some part of its surface. It has been found that glasses which retain their original "fire finish" are stronger, for equal thicknesses, than those of which the surfaces have been obtained by grinding. This, of course, is a strong point in favour of float glass.

SURFACE PLATES AND TOOLING GAUGES—Glass is an ideal material for the toolroom, since it does not rust or corrode, and is much lighter than iron or steel; it will not burr, and indentation will not destroy the surface flatness. Very fine limits are possible in plates made from 1 in. polished plate glass, since the fine grade matt surface finish obviates glare and "ringing". An additional advantage is that of greater visibility during inspection.

HEAT-ABSORBING GLASS—provides an excellent solution to the problem of restraining solar radiant heat while admitting the light rays without serious reduction in intensity. This filtering phenomenon is useful in many spheres, some factories even depending for their successful functioning upon effective thermal control of the inside atmosphere.

INSPECTION GLASSES—In glasses for furnace inspection, welding, etc., the main object is the reduction of light intensity and heat radiation. In addition, glass such as that used in the Klinger water gauge permits visible inspection of water levels while resisting the effects of high steam

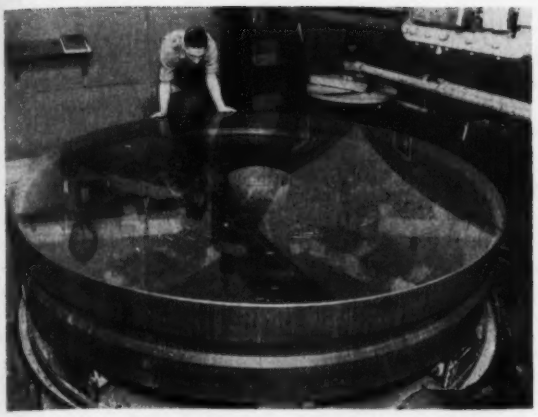


Fig. 6. 98 in. telescope mirror, after grinding (Howard Grubb Parsons & Co. Ltd.).

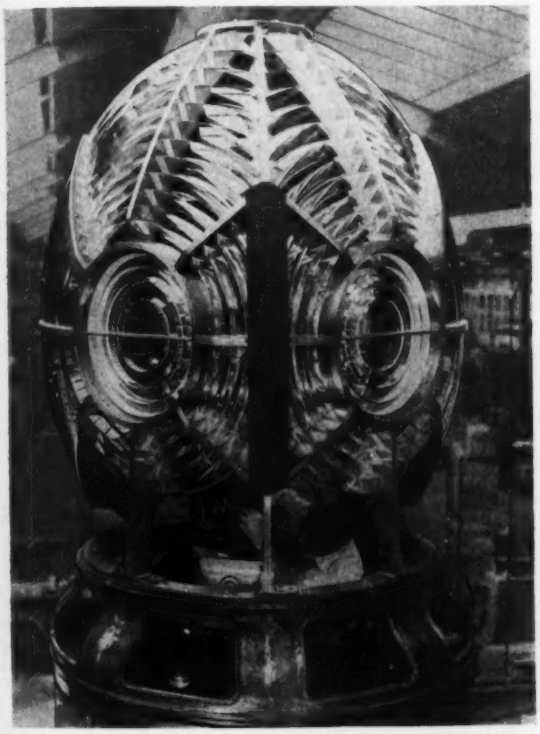


Fig. 7. Optical apparatus as fitted to the Dwarka lighthouse, in India (Stone Chance Ltd.).

pressure and temperature. In research work concerning the direction of water currents in high-pressure boilers, an inspection box having an armourplate glass cover is mounted in a situation where the circulation can be studied. Erosion of the glass must be checked frequently where sight glasses are in direct contact with hot water under high steam pressure, and precautions taken to ensure replacement before deterioration has gone too far.

BULLET-RESISTING GLASS—A laminated form of safety glass is usually used where "bullet-proof" glass is required, varying in thickness from 1 to 3 in. Low absorption of light is a feature of this glass, to avoid loss of visibility when travelling at high speeds due to the multiplicity of reflecting surfaces.

GLASSED STEEL—A process of coating steel which has made tremendous advances in many fields is that known as Pfaudler glassed-steel. Reservoirs are treated to provide this easily cleaned condition, and valves and other fittings have their vital surfaces similarly processed. Since glass is a non-absorbent, non-corrosive, hygienic material, it will readily withstand extremes of temperature without failing. Glass-lined steel combines the cleanliness of glass with the strength and durability of steel when it is maintained in the proper manner.

VITREOUS ENAMELLING—of sheets of steel or aluminium promises much for the future in decorative and utility finishes. Among the attractive qualities of this surface are high resistance to abrasion, scratching and corrosion (especially that due to atmospheric pollution), and freedom from fading.

MOULDED AND FABRICATED GLASS FIBRE—Much use is made today of glass-reinforced plastics. In the Orient liner *Canberra*, for example, many sections of the passenger accommodation have been made from moulded glass-reinforced plastics. A factor of considerable importance to the manufacturer nowadays is the vastly increased knowledge of the resins most suited to the effective impregnation of the glass fibre. German investigations into the possibility of fabricating chains from glass-fibre reinforced resin have proved most successful, and, as Fig. 5 shows, they can be employed on a large variety of jobs; being rather costly to produce, they cannot be used as extensively as steel and iron chains, but since they have a low specific weight and a breaking strength of from 65 to 90 per cent. of that of a steel chain of comparable size, there are many spheres where they are actually superior to their mild-steel rivals.

FOAMGLAS—(registered trade-mark of the Pittsburgh Corning Corporation). This is an insulating material made from a mixture of finely powdered glass and a cellulating agent (such as carbon) similarly treated. In the intense heat of a furnace, the mixture cellulates and "rises". The resulting cellular glass consists of countless tiny closed cells in the form of large "biscuits", which are then stripped from their pans and fed into a long annealing surface, from which they are later taken for cutting and trimming to size. Blocks of 12 × 18 and 18 × 24 in. are normal marketed sizes.

CHEMICAL INDUSTRY—As regards first cost, glass equipment will in general bear comparison with most other constructional materials, though for many purposes it competes directly with stainless steel, nickel alloys and carbon. Glass proves easily the most attractive, by virtue of its high chemical endurance and consequent longer service life.

GLASS IN ASTRONOMY—Glass figures largely in the production of modern telescopes. A vital unit is the mirror provided for the reflection of the objects upon which the astronomer's attention is focused. In the past these mirrors were made of a special bronze known professionally as speculum metal, but as the size of telescopes increased the larger mirrors required became more difficult to produce in metal, and extremely liable to errors as a result of temperature changes and exposure to the atmosphere. As the correctness of the astronomer's findings hinges on complete accuracy of the mirror, some alternative to the metal unit had to be found. The discovery of the silvering process for glass mirrors indicated glass as the obvious answer, yielding a reflector that, notwithstanding all the problems involved in its production, has nevertheless satisfied the astronomer's demands more completely than its predecessor.

LIGHTHOUSES—The projection of a powerful beam of light from a lighthouse over many miles of ocean is the result of long experience in the mounting of skilfully ground glass prisms.

PHOTOGRAPHY—Notwithstanding the extensive use of roll and cut film for photographic purposes, glass maintains its prominent position in the photographic world. With the increasing number of operators, even the lens maker has to adopt mass-production methods to keep pace with the

demand. An attempt was made many years ago to popularise "pin-hole" photography, but exposures were too slow and the swing now is in reverse, for big aperture lenses using such stops as f2 and even larger with ultra-rapid exposures to cover fast-moving objects with sharp definition.

SINTERED GLASS—In powder metallurgy, metal parts are made by pressing (or briquetting) the metal powder to size, then heat-treating (sintering). A similar technique may be employed to process glass powders. After sintering, the parts may in some cases be given a sizing operation. With the finer particles obtained by ball milling, and by firing at higher temperatures, the body becomes consolidated and less porous. The inclusion of small amounts of gas in minute voids, usually around 2 per cent of the volume, makes the material translucent in a manner similar to opal glasses. This method of fabrication, termed "multi-form", can be used with many glass compositions. The principal limitation is the tendency of some glasses to devitrify during the firing operation.

Two methods are used for forming the article previous to firing—slip casting and dry pressing—both of which are common ceramic operations. For slip castings, the powdered glass is made into a liquid slip which is poured into a plaster of paris mould which absorbs the water from the slip. The casting is dried further after removal from the mould, before firing. In the dry-pressing operation, a small amount of organic binder is mixed with the glass, which forms small granules. These granules are fed into steel dies mounted in a ceramic-type press. The green strength of the pressed article is produced by the binder, which must be of a type which is driven off in the firing operation without leaving an ash.

Both methods of forming permit the making of shapes which cannot be easily formed by conventional methods of glass manufacture. This applies particularly to articles with holes. Slip casting is used mainly for articles of moderate or large size made in very limited quantities, where an additional advantage is obtained from the use of the low-cost plaster of paris moulds. Glasses of the 96 per cent silica type are adaptable to slip casting; this material is also suitable for refractory parts for special applications. A modified slip of this material has been used successfully in making ceramic moulds for the casting of high-temperature and other alloys. Good precision and detail are obtained in the metal castings, so that the process is suitable for the production of such parts as turbine blades for jet engines. The moulds will withstand extremely severe thermal shocks in the casting operation without cracking. The dry-pressing operation is used largely for small particles such as sealing beads, which are made in large quantities. The properties of glasses fabricated by these methods correspond closely to those obtained with other methods.

STUD WELDING TO THIN SHEET

AS far back as the 1890s stored electrical energy had been suggested for various welding processes. The use of large capacity "condensers", to use the old term, was suggested long before such devices were commercially available.

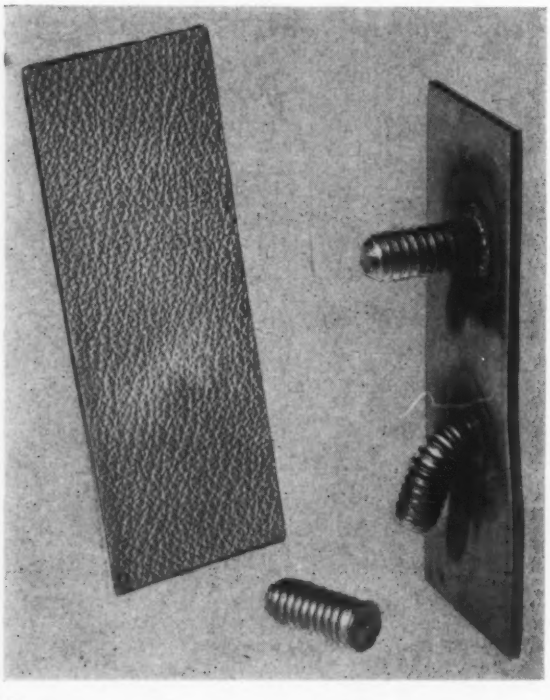
For some years now, equipment using this principle has been available in the U.S.A. for the attachment of small diameter studs of both ferrous and non-ferrous material to similar or dissimilar plate. Equipment manufactured in England based on the American design will shortly be available to the British market.

The main components of the new equipment consist of:

1. *A large bank of capacitors*, 100,000 M.F.D. being about the minimum for practical purposes.
2. *A power pack* of sufficient size to charge these capacitors, after their complete discharge, some ten or twelve times a minute.
3. *A variable transformer* enabling accurate charging of the capacitors to any predetermined amount. In practice, they are charged to a specific voltage which is indicated on a meter, this voltage being selected by reference to charts, or after a while from experience.
4. *A switch* for making contact to the capacity bank and automatically charging these capacitors after their discharge. In practice, this is, in fact, a specially designed contactor.
5. *Associated circuitry* to ensure repetitive accuracy, and to provide fool- and shock-proof operation.
6. *A gun or handtool* and associated cables. This handtool is small and light. The mechanism is very simple, consisting of a replaceable chuck, press switch and return spring, together with control and welding cable connections.

One obvious advantage which the method has over conventional arc-stud welding is that the equipment only requires connecting to a single-phase domestic power socket. This is of immense consequence on site work, when three-phase current is seldom available (even when it is, heavy cabling restricts mobility).

It is claimed that, in the diameter range of 6 BA to ¼ in., studs or attachments may be successfully welded to much thinner plate than is the case when conventional arc-stud welding equipment is employed. At present there are many applications where attachments have to be welded to 22 gauge material, and this is successfully accomplished with no marking of the underside of the plate.



Data by courtesy of K.S.M. Stud Welding Ltd.

(*Left*) Capacity discharge stud welding on to plastics coated steel (Stelvetite) does not discolour the plastics backing. The lower welded stud has been bent over after welding to show that the weld is strong enough to distort the base metal. The stud before welding (*bottom centre*) shows the contact pip and slightly enlarged base.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

New Synthetic Fibre

Unlike other synthetic fibres, the material known as vinal or vinilon (made from polyvinyl alcohol) is hygroscopic. The knitted fabric and cloth made from these fibres is characterised by warmth, strength, wear resistance (it is said to be twenty times superior to wool and five times better than cotton), and resistance to the influence of acids, alkali, salt solutions, sea water, fats and many chemicals. The thermal conductivity of the fibre is considerably lower than that of cotton, and approaches that of wool. It may be subjected to hot ironing without damage (it does not soften at temperatures up to 220 deg. C.), retains its shape and dimensions during washing and dries easily.

The properties of this fibre open up wide possibilities for its use in the textile industry, as well as for other items such as nets for river and sea fishing, ropes, lines, and covers for ships' hatches. In this field it not only replaces natural fibres, but is also being used, in Japan for instance, instead of nylon.

The structure of polyvinyl alcohol offers many possibilities for changing the properties by subjecting it to reactions in its polymer chains. On this basis, besides the usual type of fibre made water resistant by acetalisation using formaldehyde, there may be obtained a series of synthetic fibres differing according to the method by which they are reduced.

Quality Inspection of Winding Insulation

The efficiency of resin-impregnated winding insulation depends on process factors such as viscosity, quantity of solvent and behaviour under temperature and pressure or vacuum, both of which will affect the dielectric and thermal properties. A useful means of assessing the quality of the insulation by a combined method of microscope observation and thermal testing is outlined in an Italian journal, *L'Energia Elettrica.*

Using this method, the loss angle factor is measured while the windings are subjected to increasing test voltages. With porous materials, the value remains relatively constant up to a certain threshold voltage, and then, due to ionisation, rises sharply, the gradient and threshold value varying with the type of varnish and the process involved. Subsequent microscope inspection permits physical interpretation of the electrical results. Finally, the overall conductivity coefficient is measured on selected windings before and after treatment. A comparison of results against a datum provided by direct visual means assumes particular significance, especially in the case of different processes using varnishes of the same base.

Substitute for Mica

At the Moscow Chemico-Technological Institute a mica substitute consisting of very thin glass films has been developed. If the thickness of sheet glass is reduced from 8 mm. to 30 microns, the transverse (bending) strength of the glass under a steady load increases by a factor close to 9. There is a particularly big increase of strength when the thickness of the glass becomes less than 100 microns.

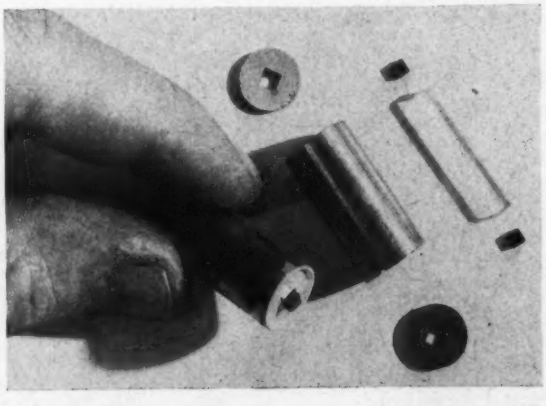
"Glass Mica" consisting of glass films is not inferior to natural mica in so far as its properties are concerned. On the contrary, the substitute has a number of advantages, one of which is that, by changing the composition of the glass, products with the better dielectric characteristics can be manufactured, whereas those of natural mica cannot be changed. Glass mica is characterised by a high degree of light transmission, adequate flexibility and excellent mechanical and insulating characteristics.

High-frequency Transducer

A new device for converting electrical energy into ultrasonic energy and vice versa at microwave frequencies was recently announced by the Bell Telephone Laboratories. The new device, a piezo-electric transducer utilising a semiconductor depletion layer, is expected to be employed primarily in ultrasonic delay lines, where its operation at high frequencies and wide bandwidths will make it possible to store large amounts of information. Another possible use will be as a tool for studying the acoustical properties of materials at high ultrasonic frequencies.

The new transducer consists of a plate of piezo-electric semi-conductor material, such as gallium arsenide, on which a thin metal film is deposited. The film constitutes a non-ohmic rectifying contact which causes a depletion layer to form, a depletion layer being a thin region of high resistivity that forms at the interface of two dissimilar materials such as a p-n junction in a semi-conductor or a rectifying metal to semi-conductor contact. The difference in Fermi levels of the two adjacent materials usually gives rise to an internal electric field which sweeps or depletes the thin interface region free of mobile charge carriers, thereby increasing its resistance. The thickness of the depletion layer can be controlled with a negative bias voltage across the interface.

When an a.c. voltage is applied, most of the voltage drop occurs across the layer, which behaves in a manner similar to a very thin piezo-electric crystal which is bonded to a solid. Since the layer is very thin, 10^{-3} to 10^{-5} cm., the electric field is very large, and considerable piezo-electric stress can be produced in the layer. In experiments, the new transducers operated at a frequency of 830 Mc., but with improvements in circuit design and fabrication the range is expected to reach 10,000 Mc.



Portable Foam Production Unit

Coincident with the development of a urea-formaldehyde resin foam called Uropor, the Austrian firm of Kreidl K.G. have produced the S.I.P. foaming gun for applying this foam directly *in situ*. The foam is of an open cell form, each cell being interconnected. Thus it is possible for this insulating material to breathe; at the same time it is flame resistant in accordance with the German specification D.I.N. 4102.

The gun, which is provided with a flexible nozzle for applying the foam in restricted areas, has a single push-button operating control, and is connected to the pumps and control device by three pipes—one for the resin, one for the hardener, and one for the source of air power for foaming. Gelling time is about 60 sec., and the consistency of the foam when hard approximates to that of cottonwool, shrinkage being as low as 0·1-0·5 per cent while drying naturally. The foam is heat resistant up to at least 150 deg. C.

Porous Stainless-steel Panels

The problems inherent in the flow of fine powdered materials include bridging and caking, causing uneven flows, while the increasing use of automatic feed equipment requires the use of storage bins with controlled output rates. When the flow is to a weighing system, the lack of a reliable feed becomes critical. Where vibrators or shakers are unable to provide satisfactory results, a solution may be found by aerating or fluidising the powder by means of inert gas or compressed air blown into the packed, almost solid mass of powder. The Micro Metallic Division of Pall Corporation, U.S.A., has achieved this without alteration to existing bins by blowing the gas or air through porous stainless-steel panels lining the bin, and through additional probes, thus providing a gaseous coated frictionless bin wall.

In developing this idea, the initial trials were made with a variety of materials including porous stone and woven fabrics, but these proved unsatisfactory. Further investigations showed that, for large panels of uniform porosity, sintered porous stainless steel possessed the right combination of properties needed for creating and dispersing a multitude of fine gas bubbles and ensuring that the product would not become contaminated. The uniform porosity with a controlled pressure drop saved a considerable quantity of gas, only 25 per cent being required as compared with panels made from other materials. The design is such that the four panels in the throat of each bin may be hung on the existing walls of the bin, thus obviating the necessity for any major alteration to existing construction.

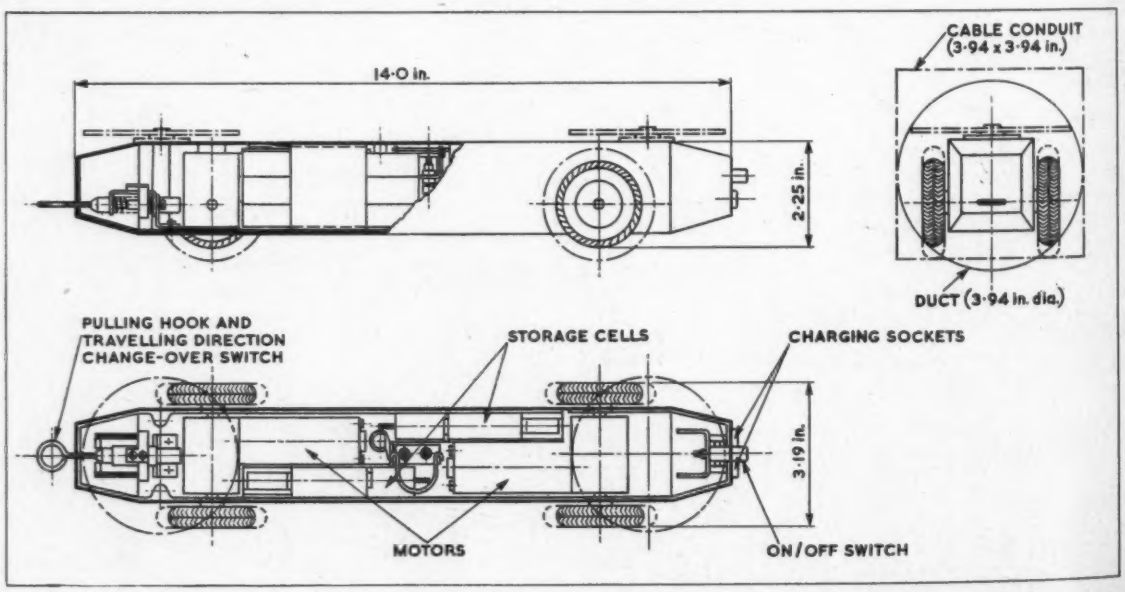
Nailing in Concrete

It has been reported in a Russian journal that the Building Research Institute in that country has devised a means whereby ordinary nails may be easily driven into prepared holes in concrete, and yet require considerable effort to withdraw them. The holes are prepared during pouring of the concrete, by fixing hook-shaped patterns made from a flexible material, such as rubber, plastics or soft metal, to the inner face of the shuttering. When the shuttering is removed, the forms can be easily extracted from the holes. It is said that a force of some 450 lb. is required to wrench out a 4 in. nail driven to conform to the shape of the prepared holes. The process provides a quick and cheap method for joining various members together.

Mechanical Ferret

A mechanical ferret or drawing-in device has been developed by Siemens & Halske, of Munich, West Germany, and is so dimensioned that it can run through conduits with a circular or square cross-section of 3·94 in., pulling a perlon thread behind it. The device is driven by two electric motors which are fed by six gas-tight steel storage cells, each set of which is interchangeable. Each motor is provided with integral gearing driving one pair of rubber-tyred wheels, the on/off switch being actuated by means of a rotary button projecting from the front end; the two sockets for connecting the charging device are arranged below this button. The pulling hook for attaching the perlon thread also serves as a switch for changing the travelling direction.

A spool, which is attached to a holding device with guiding tube, carries approximately 500 ft. of thread, the guiding tube being inserted into the cable duct while the drawing-in device travels through the conduit. If, while travelling through the conduit, the device is confronted with an obstacle and is thus stopped, it can be returned to its starting point by pulling the perlon thread. The increased tension on the thread pulls out the hook which operates the travelling direction switch. The built-in storage cells have a potential of 7·2 V. in a charged state, the minimum operating potential being 6 V.



STANDARD BOLTS AND SCREWS

UP TO 1·0 IN. DIA. (see note on page 385)

Engineering Materials and Design
DATA SHEET No. 62

BA THREADS TO BS 93

HEXAGON

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
A	0·413	0·365	0·324	0·282	0·248	0·220	0·193	0·152	0·117				BS 57
E	0·48	0·42	0·37	0·33	0·29	0·25	0·22	0·18	0·14				
B	0·177	0·156	0·139	0·121	0·106	0·094	0·083	0·065	0·050				
R									0·007				
		0·015				0·010							
A			0·324		0·248		0·193						A 25, A 26, A 28 (4 and 2 BA only), A 30 (2 BA only)
E			0·37		0·29		0·22						
B			0·113		0·086		0·068						
R			0·020		0·015		0·015						
A			0·324										A 59
E			0·37										
B			0·083										
R			0·020										
A			0·248										AS 2504 AS 4569
E			0·29										
B			0·092										

COUNTERSUNK

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
Countersunk and raised countersunk													
A	0·413	0·366	0·319	0·283	0·252	0·221	0·194	0·157	0·112	0·095	0·064	0·058	A 33, A 37 (2, 4, 6, 8, 10 and 12 BA only), A 41, A 45
B	0·099	0·089	0·077	0·071	0·065	0·058	0·051	0·043	0·030	0·028	0·019	0·019	
M	0·048	0·042	0·036	0·035	0·029	0·026	0·023	0·019	0·013	0·012	0·008	0·006	A 34, A 38 (2, 4, 6, 8 and 10 BA only), A 42, A 46, BS 57 (Slotted head)
Countersunk													
A			0·326		0·252								AS 1242 AS 2920 AS 4563 (Slotted head)
B			0·082		0·064								
Raised countersunk													
A			0·320		0·250								AS 1244 AS 2921 AS 4564 (Slotted head)
B			0·078		0·064								
M*			0·220		0·180								
Countersunk and raised countersunk													
A			0·20		0·250								AS 3294 AS 3295 (Recessed head)
B			0·08		0·070								
M*			0·35		0·27								
Countersunk and raised countersunk													
A			0·370		0·280								AS 3297 (2 BA only) AS 3296 (Recessed head)
B			0·070		0·060								
M*			0·553		0·348								

* *These dimensions are for the radius of head from which M can be obtained.*

UNFOLD REFERENCE PAGE 385

CHEESE AND ROUND

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
Round and Cheese													
A	0·413	0·366	0·319	0·283	0·252	0·221	0·194	0·157	0·112	0·095	0·064	0·058	A 31, A 32, A 35, A 36, A 39, A 40, A 43, A 44, BS 57 (2, 4, 6, 8, 10 and 12 BA only) (Slotted head)
B	0·167	0·148	0·130	0·113	0·101	0·088	0·078	0·063	0·045	0·038	0·026	0·023	
R	0·015				0·010				0·007	0·005	0·003	0·003	
Round													
A			0·35		0·27								AS 4597 (Recessed head)
B			0·13		0·11								
Round													
A			0·32		0·25								AS 1246, AS 2922, AS 4565 (Slotted head)
B			0·11		0·09								
Raised Cheese													
A	0·413	0·366	0·319	0·283	0·252	0·221	0·194	0·157	0·112	0·095	0·064	0·058	BS 57 (Slotted head)
B	0·163	0·144	0·126	0·111	0·099	0·086	0·076	0·061	0·043	0·037	0·025	0·022	
K	0·215	0·189	0·165	0·149	0·131	0·144	0·101	0·082	0·058	0·050	0·034	0·029	
R	0·015				0·010				0·007	0·005	0·003	0·003	

CONNECTION

	0	1	2	3	4	5	6	8	10	12	14	16	Specification
A	0·473	0·413	0·366	0·319	0·283	0·252	0·221	0·173	0·128	0·110	0·081	0·064	BS 57 (Slotted head)
B	0·168	0·146	0·130	0·113	0·100	0·088	0·078	0·061	0·046	0·039	0·028	0·023	
R	0·015				0·010				0·007	0·005	0·003	0·003	

MUSHROOM

A			0·42		0·32								AS 4598 (Recessed head)
B			0·12		0·09								
A			0·438		0·375								AS 1248, AS 2923, AS 4566 (Slotted head)
B			0·10		0·075								

BSW AND BSF THREADS TO BS 84

HEXAGON

	$\frac{1}{8}$ (BSW only)	$\frac{5}{32}$ (BSW only)	$\frac{3}{16}$	$\frac{7}{32}$ (BSF only)	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1·0	Specification
A					0·445	0·525	0·600	0·71	0·82	0·92	1·01	1·20	1·30	1·48	BS 1083
E					0·51	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·50	1·71	
B					0·19	0·22	0·27	0·33	0·38	0·44	0·49	0·60	0·66	0·77	
R					$\frac{1}{32}$										
A					0·445	0·525	0·600	0·71	0·82	0·92	1·01	1·20	1·30	1·48	A 61 ($\frac{1}{4}$ to $\frac{1}{2}$), A 25, A 26, A 28 ($\frac{1}{4}$ to $\frac{1}{2}$), A 30 ($\frac{1}{4}$ to $\frac{1}{2}$)
E					0·51	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·50	1·71	
B					0·15	0·18	0·22	0·27	0·30	0·35	0·39	0·48	0·53	0·62	
R					0·03										
A					0·445	0·525	0·600	0·71	0·82						A 59
E					0·51	0·61	0·69	0·82	0·95						
B					0·12	0·15	0·19	0·24	0·27						
R					0·03										
A	0·220	0·249	0·324	0·413											BS 450
E	0·254	0·286	0·374	0·477											
B	0·076	0·094	0·112	0·130											
R	0·010	0·015	0·015	0·015											

HEXAGON (cont.)

	1/8 (BSW only)	5/32 (BSW only)	3/16	7/32 (BSF only)	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A					0·445	0·525	0·600	0·710	0·82	0·92	1·01	1·20	1·30	1·48	BS 916
E					0·51	0·61	0·69	0·82	0·95	1·06	1·17	1·39	1·50	1·71	BS 916
B*					0·186	0·228	0·27	0·312	0·363	0·405	0·447	0·530	0·623	0·706	BS 916
B					0·176	0·218	0·260	0·302	0·343	0·375	0·417	0·500	0·583	0·666	BS 916
R*					← 1/32 →					← 3/64 →			← 1/16 →		BS 916
R					← 1/32 →										BS 916
A					0·324	0·445	0·525	0·600	0·71						A 57 / A 60
E					0·37	0·51	0·61	0·69	0·82						A 57 / A 60
B					0·13	0·13	0·13	0·13	0·13						A 57 / A 60
R					← 0·015 →										A 57 / A 60

* *These dimensions apply to forged heads.*

COUNTERSUNK

	1/8 (BSW only)	5/32 (BSW only)	3/16	7/32 (BSF only)	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
Countersunk and raised countersunk															
A	0·219		0·328	0·383	0·438	0·547	0·656	0·766	0·875	0·984	1·094	1·312			BS 450 (Slotted and recessed head)
B	0·056		0·084	0·098	0·113	0·141	0·169	0·197	0·225	0·253	0·281	0·338			BS 450 (Slotted and recessed head)
M	0·026		0·040	0·044	0·051	0·068	0·080	—	—	—	—	—			BS 450 (Slotted and recessed head)
Countersunk															
A					0·442	0·553	0·664	0·774	0·885						AS 1242 / AS 2920 / AS 4563 (Slotted head)
B					0·110	0·139	0·168	0·196	0·225						AS 1242 / AS 2920 / AS 4563 (Slotted head)
Raised countersunk															
A					0·440	0·550	0·660	0·760	0·880						AS 1244 / AS 2921 / AS 4564 (Slotted head)
B					0·105	0·129	0·153	0·171	0·200						AS 1244 / AS 2921 / AS 4564 (Slotted head)
M*					0·31	0·38	0·46	0·53	0·62						AS 1244 / AS 2921 / AS 4564 (Slotted head)
Countersunk and raised countersunk															
A					0·44	0·57	0·65								AS 3294 / AS 3295 (Recessed head)
B					0·11	0·15	0·16								AS 3294 / AS 3295 (Recessed head)
M*					0·50	0·63	0·75								AS 3294 / AS 3295 (Recessed head)
Countersunk and raised countersunk															
A					0·50	0·63	0·75								AS 3296 / AS 3297 (Recessed head)
B					0·09	0·12	0·14								AS 3296 / AS 3297 (Recessed head)
M*					0·709	0·962	1·063								AS 3296 / AS 3297 (Recessed head)

* *These dimensions are for the radius of head from which M can be obtained.*

ROUND

	1/8 (BSW only)	5/32 (BSW only)	3/16	7/32 (BSF only)	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·219		0·328	0·383	0·438	0·547	0·656	0·766	0·875	0·984	1·094	1·312			BS 450 (Slotted head)
B	0·087		0·131	0·153	0·175	0·219	0·262	0·306	0·350	0·394	0·437	0·525			BS 450 (Slotted head)
R	0·010		0·015	0·015	← 0·031 →										BS 450 (Slotted head)
A	0·236		0·359	0·408	0·472	0·590	0·708								BS 450 (Recessed head)
B	0·095		0·137	0·153	0·175	0·216	0·256								BS 450 (Recessed head)
R	0·010		0·015	0·015		← 0·031 →									BS 450 (Recessed head)
A					0·440										AS 1246 / AS 2922 / AS 4565 (Slotted head)
B					0·15										AS 1246 / AS 2922 / AS 4565 (Slotted head)
A					0·47	0·59	0·71								AS 4597 (Recessed head)
B					0·18	0·21	0·25								AS 4597 (Recessed head)

There is a saying that whereas
there are a hundred ways of doing a thing wrongly
there is only one way of doing it correctly.

GKN have one way of making fifty or sixty thousand different fastenings—the right way.

GUEST KEEN & NETTLEFOLDS (MIDLANDS) LTD.

BOLT & NUT DIVISION: ATLAS WORKS, DARLASTON, S. STAFFS. TELEPHONE: JAMES BRIDGE 3100 (10 LINES). TELEX: 33-228

SCREW DIVISION: BOX 24, HEATH STREET, BIRMINGHAM 18. TELEPHONE: SMETHWICK 1441. TELEX: 33-239

o/gs/40

PAN

	1/8 (BSW only)	5/32	3/16	7/32 (BSF only)	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A	0·245		0·373	0·425	0·492	0·615	0·740	0·863	0·987	1·031	1·125	1·25			BS 450 (Slotted and recessed head)
B*	0·075		0·110	0·125	0·144	0·178	0·212	0·247	0·281	0·315	0·350	0·419			
B†	0·089		0·113	0·151	0·175	0·218	0·261	0·304	0·348						
R	0·010		0·015	0·015	0·031										

* Slotted head.
† Recessed head.

CHEESE

Cheese															
A	0·188		0·281	0·328	0·375	0·469	0·562	0·656	0·750	0·844	0·938	1·125			BS 450 (Slotted head)
B	0·087		0·131	0·153	0·175	0·219	0·262	0·306	0·350	0·394	0·437	0·525			
R	0·010		0·015	0·015	0·031										
Raised cheese															
A	0·205		0·313	0·357	0·414	0·518	0·622	0·625	0·750						BS 450 (Recessed head)
B	0·083		0·124	0·142	0·163	0·199	0·260	0·284	0·311						
K	0·120		0·180	0·205	0·237	0·295	0·355	0·368	0·412						
R	0·010		0·015	0·015	0·031										

MUSHROOM

A	0·289		0·448		0·573	0·698	0·823								BS 450 (Slotted and recessed head)
B	0·078		0·118		0·150	0·183	0·215								
R	0·010		0·015		0·031										
A					0·625	0·75									AS 1248 AS 2923 AS 4566 (Slotted head)
B					0·125	0·18									
A					0·57	0·69	0·82								AS 4598 (Recessed head)
B					0·15	0·21	0·24								

UNIFIED THREADS TO BS 1580

HEXAGON

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0	Specification
A					0·438	0·500	0·563	0·625	0·750		0·938	1·125	1·313	1·500	BS 2708 (Forged or faced) BS 3139 (Faced)
E					0·505	0·577	0·650	0·722	0·866		1·083	1·299	1·516	1·732	
B*	(UNC only)				0·183	0·231	0·263	0·311	0·353		0·433	0·513	0·605	0·667	
B†					0·163	0·211	0·243	0·291	0·323		0·403	0·483	0·563	0·627	
R*	(UNC only)				1/32					3/32	5/64		1/16		
R†					←					→					
A					0·438	0·500	0·563	0·625	0·750	0·813	0·938	1·125	1·313	1·500	BS 1768
E					0·505	0·577	0·650	0·722	0·866	0·938	1·083	1·229	1·516	1·732	
B					0·16	0·21	0·24	0·29	0·32	0·37	0·40	0·48	0·56	0·63	
R					1/32										
A									0·875		1·063	1·250	1·438	1·625	BS 1769
E									1·010		1·230	1·440	1·660	1·880	
B*									0·458		0·553	0·649	0·745	0·840	
B†									0·426		0·522	0·618	0·714	0·778	
R									1/16		1/16				
A	0·188	0·250	0·312	0·344	0·438	0·500	0·563	0·688	0·750	0·875	0·938	1·063	1·250	1·438	AS 1 ($\frac{1}{4}$ to $\frac{1}{2}$ and 10/32) A 102 A 104 A 106 ($\frac{1}{4}$ to $\frac{3}{8}$) A 108 ($\frac{1}{4}$ to $\frac{1}{2}$ and 10/32) A 111 ($\frac{1}{4}$ to $\frac{1}{2}$ and 10/32)
E	0·217	0·289	0·361	0·397	0·505	0·577	0·650	0·794	0·866	1·010	1·083	1·227	1·443	1·660	
B	0·07	0·085	0·10	0·115	0·15	0·18	0·22	0·27	0·30	0·35	0·39	0·48	0·53	0·62	
R	0·015	0·015	0·02	0·02	0·03										

* Forged heads.
† Faced heads.

EMD 6662 for further information

BACKED BY MORE RESEARCH THAN ANY OTHER SCREW

Unbrako are making screws now to take strains which are still drawing board calculations. That is what Unbrako's genuine five-year lead means to industry. Designers can plan ahead in the confidence that the fasteners they will need already exist.

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UNBRAKO SCHRAUBEN Gm. b. H. KOBLENZ
UNBRAKO STEEL CO. LTD. SHEFFIELD, ENGLAND

HEXAGON (cont.)

	4/40	6/32	5/32	10/24 10/32	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1·0	Specification
A					0·375	0·438	0·500	0·563	0·688	0·750	0·875	0·938			A 109 A 112
E					0·433	0·505	0·577	0·650	0·794	0·866	1·010	1·083			
B					← 0·13 →										
R					← 0·03 →										
A		0·250	0·312	0·344	0·438	0·500	0·562	0·688	0·750	0·875	0·938				A 169
E		0·289	0·361	0·397	0·505	0·577	0·650	0·794	0·866	1·010	1·083				
B		0·085	0·100	0·115	0·150	0·180	0·22	0·27	0·30	0·35	0·39				
R		0·015	0·02	0·02	← 0·03 →										
A	0·188	0·250	0·250	0·313											BS 1981
E	0·216	0·289	0·289	0·361											
B	0·06	0·08	0·11	0·12											
R	0·01	0·01	0·015	0·015											

COUNTERSUNK

	4/40	6/32	8/32	10/24 10/32	¼	5/16	⅜	7/16	½	9/16	⅝	¾	Specification
Countersunk and raised countersunk													
A	0·211	0·260	0·310	0·359	0·473	0·593	0·712	0·753	0·808		1·041	1·275	BS 1981
B	0·067	0·083	0·100	0·116	0·153	0·191	0·230	0·223	0·223		0·298	0·372	
M	0·024	0·030	0·036	0·041	0·055	0·070	0·086	—	—		—	—	
Countersunk													
A			0·287	0·337	0·452	0·572	0·692	0·812	0·932				A 173, A 174, A 175
B			0·068	0·080	0·106	0·133	0·159	0·186	0·213				AS 2 (¼ to ½, and 10/32)*
Countersunk													
A					0·45	0·56	0·67	0·77	0·89				A 119 A 120
B					0·105	0·129	0·153	0·171	0·200				A 121 A 172
Countersunk													
A	0·206	0·253	0·303	0·351									A 204 A 206
B	0·049	0·061	0·073	0·084									A 208

* *These slots are plunger milled.*

PAN

	4/40	6/32	8/32	10/24 10/32	¼	5/16	⅜	7/16	½	9/16	⅝	¾	Specification
A	0·219	0·270	0·322	0·373	0·492	0·615	0·740	0·863	0·987		1·125	1·250	BS 1981
B	0·068	0·082	0·096	0·110	0·144	0·178	0·212	0·247	0·281		0·350	0·419	
B*	0·080	0·097	0·115	0·133	0·175	0·218	0·261	0·304	0·348		—	—	
R	0·010	0·010	0·015	0·015	← 1/32 →								
A	0·194	0·252	0·283	0·319	0·440	0·547							A 116 A 118 (¾ and 5/16 only)
B	0·068	0·082	0·096	0·110	0·114	0·178							
R	0·015	0·015	0·020	0·020	0·03	0·03							
A	0·194	0·252	0·283	0·319	0·440	0·547							A 117, A 171 A 207, A 205, A 209 (4/40 to 10/32 only)
B	0·068	0·082	0·096	0·110	0·144	0·178							
R	0·005	0·005	0·010	0·010	0·015	0·015							

* *Applies to recessed heads only.*

CHEESE

	4/40	6/32	8/32	10/24 10/32	¼	5/16	⅜	7/16	½	9/16	⅝	¾	Specification
A	0·183	0·226	0·270	0·313	0·414	0·518	0·622	0·625	0·750		0·875	1·000	BS 1981
B	0·069	0·086	0·102	0·119	0·158	0·199	0·239	0·265	0·283		0·360	0·424	
K	0·107	0·132	0·156	0·180	0·237	0·295	0·355	0·368	0·412		0·521	0·612	
R	0·010	0·010	0·015	0·015	← 1/32 →								

MUSHROOM

	4/40	6/32	8/32	10/24 10/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	Specification
A		0·316	0·378	0·441	0·565	0·690							A 113, A 114, A 170
B		0·086	0·102	0·118	0·150	0·183							
R		0·015	0·020	0·020	0·030	0·030							
A					0·565	0·690							A 115
B					0·132	0·187							
R					0·030	0·030							

FLAT ROUND

Thread	10/32 UNF		1/4 UNF		5/16 UNF		3/8 UNF	
Pt. No. Series	AS 6760–6802	AS 6850–6892	AS 6895–6937	AS 6985–7027	AS 7033–7075	AS 7123–7165	AS 7171–7213	AS 7264–7306
Head size	Small	Large	Small	Large	Small	Large	Small	Large
A	0·375	0·550	0·510	0·677	0·615	0·770	0·677	0·925
B	0·125	0·150	0·150	0·150	0·175	0·175	0·200	0·200
C	0·150	0·215	0·192	0·254	0·223	0·309	0·754	0·340

(Individual part numbers according to length.)

HEXAGON SOCKET CAP, SET AND SHOULDER SCREWS

	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0
BSW and BSF Threads to BS 84; UNF and UNC Threads (1/4 and above) to BS 1580														
B			0·312	—	0·375	0·437	0·562	0·625	0·75	—	0·875	1·0	1·125	1·312
H*			0·187	—	0·25	0·312	0·375	0·437	0·5	—	0·625	0·75	0·875	1·0
R			0·012	—	0·015	0·015	0·018	0·02	0·025	—	0·025	0·03	0·03	0·04
W*			5/32	—	3/16	7/32	1/4	9/32	3/8	—	1/2	9/16	9/16	5/8
W†			3/32	—	1/4	5/16	3/8	7/16	1/4	—	7/16	1/2	1/2	7/16
A					0·248	0·311	0·373	—	0·498	—	0·623	0·748	—	0·998
H†					0·188	0·219	0·25	—	0·313	—	0·375	0·5	—	0·625
D					3/16	1/4	5/16	—	3/8	—	1/2	5/8	—	3/4
Pipe(parallel). Threads to BS 84														
W†	3/16	—	—	—	1/4	—	5/16	—	3/8	—	1/2	9/16	—	—

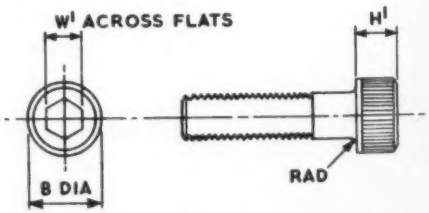
H—Cap screws.*
H†—Shoulder screws.

W—Cap and shoulder screws.*
W†—Set screws.

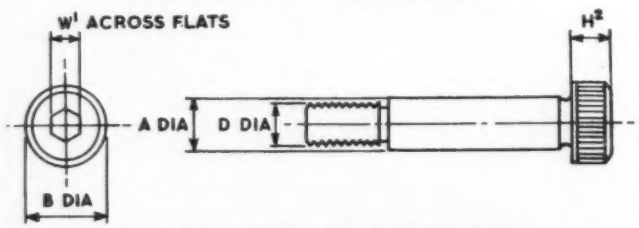
HEXAGON SOCKET CAP AND SET SCREWS TO BS 2470 (BA Threads to BS 93)

	0	1	2	3	4	5	6
B	0·375	0·312	0·312	0·25	0·219	0·219	0·187
H	0·236	0·209	0·187	0·161	0·142	0·126	0·110
R	0·015	0·012	0·012	0·010	0·010	0·010	0·008
W*	3/16	5/32	5/32	1/8	9/64	9/64	5/64
W†	1/8	3/32	3/32	3/64	1/16	1/16	0·05

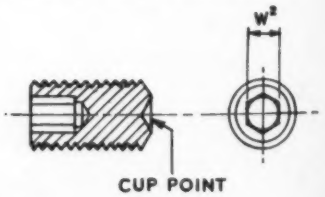
W—Sockets for cap screws. W†—Sockets for set screws.*



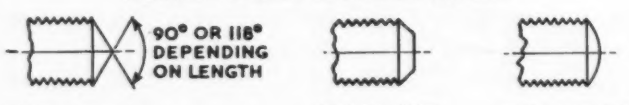
HEXAGON SOCKET HEAD CAP SCREWS



HEXAGON SOCKET SHOULDER SCREWS



HEXAGON SOCKET SET SCREWS



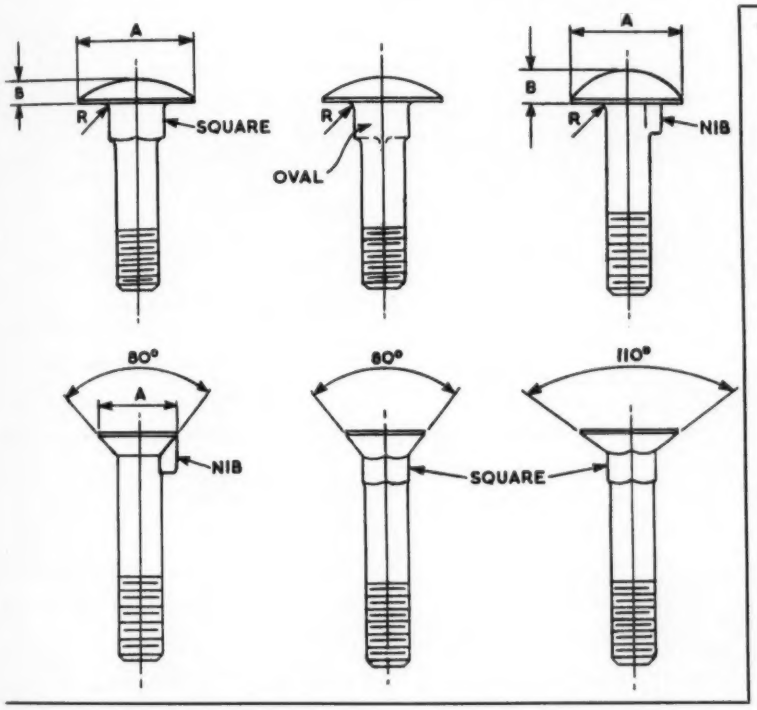
CONE POINT FLAT POINT OVAL POINT

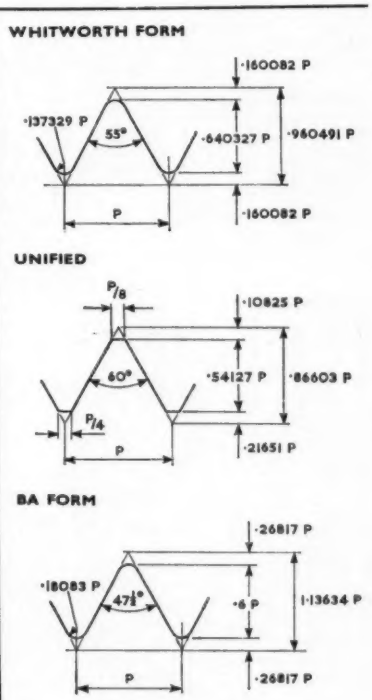
FULL DOG POINT HALF DOG POINT

BLACK CUP AND COUNTERSUNK BOLTS TO BS 325 (BSW Threads to BS 84)

	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0
A*					0·562	0·703	0·844	0·984	1·125	—	1·406	1·688	1·969	2·25
B*					0·125	0·156	0·188	0·25	0·281	—	0·375	0·438	0·5	0·562
R					<		1/32		>		3/64	3/64	1/16	1/16
A†					0·5	0·625	0·75	0·875	1·0	—	1·125	1·5	1·75	2·0
B†					0·188	0·234	0·281	0·328	0·375	—	0·469	0·562	0·656	0·75
F					—	—	—	—	—	—	—	1·0	1·125	—
A**					0·459	0·574	0·69	0·805	0·92	—	1·149	1·379	1·609	1·839
A‡					0·625	0·781	0·938	1·094	1·25	—	1·562	1·875	2·188	2·5

A* } Black cup square and oval neck bolts. (oval in 3/8 and 7/16 in. only)
B* }
A**—80° countersunk nibbed (1/4 to 1·0 in. only), and 80° countersunk square-necked bolts (1/8 to 1·0 in. only).
A† } Black cup nibbed bolts.
B† }
A‡—110° countersunk square-necked bolts.





UNIFIED THREADS

Nominal size	UNC 4/40	UNC 6/32	UNC 8/32	UNC 10/24	UNF 10/32
T.p.i.	40	32	32	24	32
Major dia.	0·112	0·138	0·164	0·190	0·190
Core dia	0·0813	0·0997	0·1257	0·1389	0·1517
Core area	0·0050	0·0078	0·0124	0·0154	0·0181
Tapping drill	43	36	30	28	23

UNF THREADS

Nominal size	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0
T.p.i.	28	24	24	20	20	18	18	16	14	12
Core dia.	0·2062	0·2614	0·3239	0·3762	0·4387	0·4943	0·5568	0·6733	0·7874	0·8978
Core area	0·0334	0·0536	0·0824	0·111	0·151	0·192	0·244	0·356	0·486	0·633
Tapping drill	3	I	Q	25/64	29/64	33/64	37/64	11/16	13/16	15/16

UNC THREADS

	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1·0
T.p.i.	20	18	16	14	13	12	11	10	9	8
Core dia.	0·1887	0·2443	0·2983	0·3499	0·4056	0·4603	0·5135	0·6273	0·7387	0·8466
Core area	0·0279	0·0468	0·0697	0·096	0·129	0·167	0·207	0·308	0·428	0·562
Tapping drill	7	F	5/16	U	27/64	31/64	17/32	21/32	49/64	7/8

BA THREADS

Nominal size	0	1	2	3	4	5	6	8	10	12	14	16
Dia.	0·236	0·209	0·185	0·161	0·142	0·126	0·110	0·087	0·067	0·051	0·039	0·031
T.p.i. (approx.)	25·4	28·2	31·4	34·8	38·5	43·1	47·9	59·1	72·6	90·7	110	134
Core dia.	0·189	0·166	0·1468	0·1268	0·1106	0·098	0·085	0·0661	0·0504	0·0011	0·0006	0·0004
Core area	0·0281	0·217	0·0169	0·0126	0·0096	0·0075	0·0057	0·0034	0·0020	0·0378	0·0283	0·0220
Tapping drill	13	20	27	31	35	41	45	51	55	62	69	74

BSW THREADS

Nominal size	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1·0
T.p.i.	40	24	20	18	16	14	12	12	11	10	9	8
Core dia.	0·0930	0·1341	0·186	0·2413	0·295	0·3461	0·3932	0·4557	0·5086	0·6220	0·7328	0·84
Core area	0·0068	0·0141	0·0272	0·0457	0·0683	0·0941	0·1214	0·1631	0·2032	0·3039	0·4218	0·5542
Tapping drill	42	29	9	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{23}{64}$	$\frac{13}{32}$	$\frac{15}{32}$	$\frac{17}{32}$	$\frac{41}{64}$	$\frac{3}{4}$	$\frac{59}{64}$

BSF THREADS

Nominal size	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1·0
T.p.i.	32	28	26	22	20	18	16	16	14	12	11	10
Core dia.	0·1475	0·1730	0·2008	0·2543	0·311	0·3663	0·42	0·4825	0·5336	0·6432	0·7586	0·872
Core area	0·0171	0·0235	0·0317	0·0508	0·0760	0·1054	0·1385	0·1828	0·2236	0·3249	0·4520	0·5972
Tapping drill	25	16	5	G	0	$\frac{9}{64}$	$\frac{21}{64}$	$\frac{1}{2}$	$\frac{33}{64}$	$\frac{51}{64}$	$\frac{55}{64}$	$\frac{57}{64}$

STANDARD SPECIFICATIONS

(Figures quoted are minimum values.)

SPECIFICATION	TITLE	MATERIAL AND REMARKS
BS 57	BA screws, bolts, nuts and plain washers.	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 325	Black cup and countersunk bolts, nut and washers (BSW).	Steel 26 t.s.i.
BS 450	Machine screws and machine screw nuts (BSW and BSF).	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 768	Slotted grub screws (BA, BSF, BSW and unified threads).	Ferrous and non-ferrous.
BS 916	Black bolts, screws and nuts (hexagon and square) (BSW and BSF).	Steel 26 t.s.i. and 20% elongation, or 28 t.s.i. and 17% elongation.
BS 1083	Precision hexagon bolts, screws, nuts and plain washers (BSW and BSF).	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 1768	Unified precision hexagon bolts, screws, nuts and plain washers (normal series).	Steel, as code number on bolt head: B = 28–35 t.s.i.; P = 35–45 t.s.i.; R = 45–55 t.s.i.; T = 55–65 t.s.i.; V = 75–85 t.s.i.
BS 1769	Unified black hexagon bolts and screws, nuts and plain washers (heavy series).	Steel to BS EN3A.
BS 1981	Unified machine screws and nuts. (Slotted & recessed heads).	Steel 25 t.s.i., brass and aluminium alloy 20 t.s.i.
BS 2470	Hexagon socket screws (BA, BSF, BSW and unified threads).	
BS 2708	Unified black square and hexagon bolts, screws, nuts and plain washers (normal series).	Steel 26 t.s.i. and 20% elongation, or 28 t.s.i. and 17% elongation.
BS 3139	High strength friction grip bolts (hexagon heads) (UNC only).	Steel (heat-treated).
BS Aircraft Series		
A 25	High-tensile-steel hexagon-headed bolts (machined from bar) (BSF).	Steel to BS S94, S95, S96, S114, S116, S117.
A 26	High-tensile stainless-steel hexagon-headed bolts (machined from bar) (BSF).	Stainless steel to BS S80.
A 28	Aluminium alloy (DTD 683) hexagon headed bolts (machined from bar) (BSF).	Aluminium alloy to DTD 683.
A 30	Close tolerance hexagon-headed bolts in high tensile steel (BSF).	Steel to BS S94, S95, S96, S114.
A 31-46	*BA low tensile screws for aeronautical purposes*	
A 31	Cheese head.	Steel 25 t.s.i.
A 32	Round head.	
A 33	Countersunk head.	
A 34	Raised countersunk head.	
A 35	Cheese head.	Stainless steel 35 t.s.i.
A 36	Round head.	
A 37	Countersunk head.	
A 38	Raised countersunk head.	
A 39	Cheese head.	Aluminium alloy 20 t.s.i.
A 40	Round head.	
A 41	Countersunk head.	
A 42	Raised countersunk head.	
A 43	Cheese head.	Brass 20 t.s.i.
A 44	Round head.	
A 45	Countersunk head.	
A 46	Raised countersunk head.	
A 57	Shear bolts and nuts for aircraft (BSF).	Steel to BS S94, S95, S114, S116, S117.
A 59	Cadmium-plated hexagon-headed steel bolts (BSF), and close tolerance shanks.	
A 60	Cadmium-plated shear bolts (BSF threads).	
A 61	Aluminium alloy hexagon-headed bolts.	Aluminium alloy to BS L65.
A 102	Steel bolts (unified hexagons and threads).	Steel to S105 (up to and including $\frac{1}{2}$ dia.), S102, S103, S105 ($\frac{1}{2}$ dia. and above).

STANDARD SPECIFICATIONS (cont.)

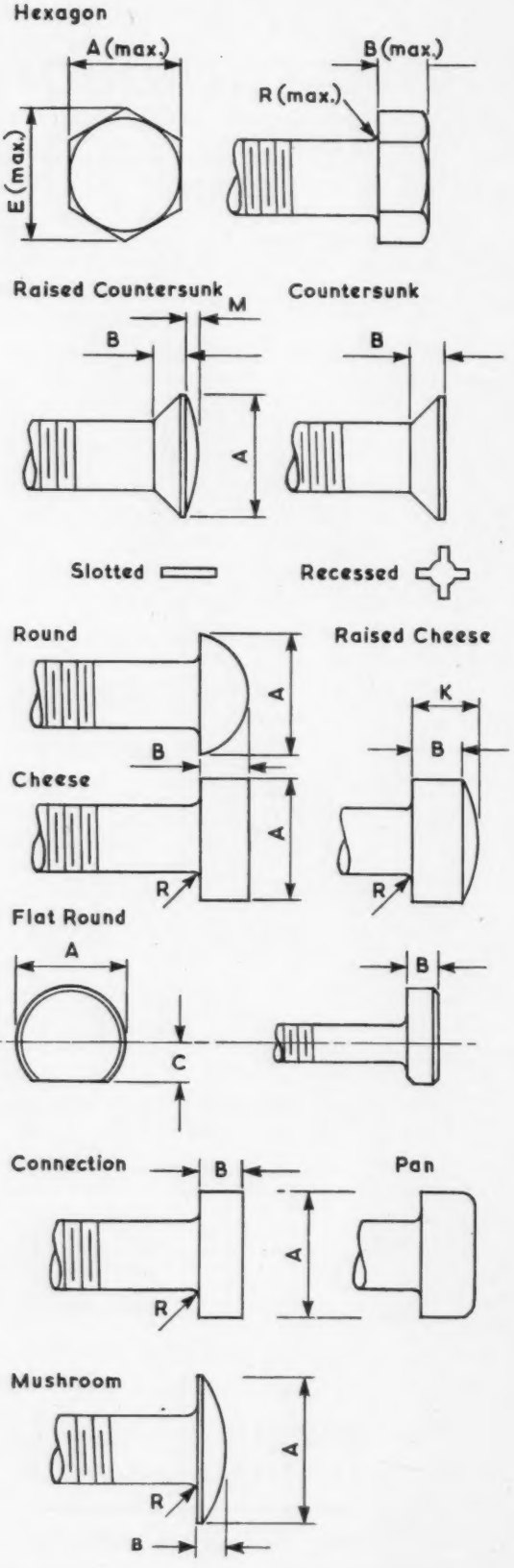
A 104	Corrosion-resisting steel bolts (unified hexagons and threads).	Stainless steel to S80.
A 106	Aluminium alloy bolts (unified hexagons and threads).	Aluminium alloy to DTD 683.
A 108	Steel bolts (unified hexagons, threads and close tolerance shanks).	Steel to S94, S95, S114, S116 ($\frac{1}{4}$ in. dia only), S117.
A 109	Shear bolts (unified hexagons and threads).	Steel to S94, S114, S95, S116 ($\frac{1}{4}$ in. dia. only), S117.
A 111	Cadmium-plated steel bolts (unified hexagons and threads), close tolerance shanks.	Steel to S94, S95, S114, S116 ($\frac{1}{4}$ in. dia. only), S117.
A 112	Cadmium-plated shear bolts (unified hexagons and threads).	Steel to S94, S95, S114, S116 ($\frac{1}{4}$ in. dia. only), S117.
A 113	Steel mushroom head bolts (unified threads).	Steel to S94, S95, S114, S116, (up to $\frac{1}{4}$ in. dia. only), S117.
A 114	Corrosion-resisting steel mushroom head bolts (unified threads).	Stainless steel to S80.
A 115	Aluminium alloy mushroom head bolts (UNF threads).	Aluminium alloy to DTD 683.
A 116	Steel pan head screws (unified threads).	Steel to S94, S95, S114, S116 (up to $\frac{1}{4}$ in. dia. only), S117.
A 117	Corrosion-resisting steel pan head screws (unified threads).	Stainless steel to S80.
A 119	90° countersunk head aluminium alloy bolts (unified threads).	Steel to S94, S95, S114, S116 (up to $\frac{1}{4}$ in. dia. only). S117.
A 120	90° countersunk head corrosion-resisting steel bolts (UNF threads).	Stainless steel to S80.
A 121	90° countersunk head aluminium alloy bolts (UNF threads).	Aluminium alloy to DTD 683.
A 169	Aluminium alloy bolts (unified hexagons and threads).	Aluminium alloy to L65.
A 170	Aluminium alloy mushroom head bolts (unified threads).	Aluminium alloy to L65.
A 171	Aluminium alloy pan head bolts (unified threads).	Aluminium alloy to L65.
A 172	90°countersunk head aluminium alloy bolts (unified threads).	Aluminium alloy to L65.
A 173	100° countersunk head steel bolts (unified threads).	Steel to S94, S95, S114, S116 (up to $\frac{1}{4}$ in. dia. only), S117.
A 174	100° countersunk head corrosion-resisting steel bolts (unified threads).	Stainless steel to S80.
A 175	100° countersunk head aluminium alloy bolts (unified threads).	Aluminium alloy to L65.
A 204-209	*Machine screws (unified threads for aeronautical purposes).*	BS1580.
A 204	Countersunk head.	Steel 25 t.s.i. minimum.
A 205	Pan head.	
A 206	Countersunk head.	Corrosion-resisting steel, minimum t.s.i. (BS 970, En 56, 57 or 58).
A 207	Pan head.	
A 208	Countersunk head.	Aluminium alloy 20 t.s.i. minimum (BS 1473, 1476).
A 209	Pan head.	
SBAC Series		
AS 1	Hexagon heads, unified threads and close tolerance shanks.	Titanium alloy.
AS 2	100° countersunk head bolts, unified threads.	Titanium alloy.
AS 1242	90° countersunk head.	High tensile steel.
AS 1244	Raised 90° countersunk head (BA and BSF).	High tensile steel.
AS 1246	Round head (BA and BSF).	High tensile steel.
AS 1248	Mushroom head. (BA and BSF).	High tensile steel.
AS 2504	Hexagon head close tolerance shanks, cadmium plated (BSF).	High tensile steel.
AS 2920	90° countersunk head (BA and BSF).	High tensile stainless steel.
AS 2921	90° raised countersunk head (BA and BSF).	High tensile stainless steel.
AS 2922	Round head, (BA and BSF).	High tensile stainless steel.
AS 2923	Mushroom head (BA and BSF).	High tensile stainless steel.
AS 3294	90° countersunk head (BA and BSF). (Recessed head)	High tensile steel.
AS 3295	Raised countersunk head (BA and BSF) (Recessed head)	
AS 3296	120° raised countersunk head (BA and BSF). (Recessed head)	
AS 3297	120° countersunk (BA and BSF). (Recessed head)	
AS 4563	90° countersunk head (BA and BSF).	Aluminium alloy.
AS 4564	90° raised countersunk head (BA and BSF).	Aluminium alloy.
AS 4565	Raised head (BA and BSF).	Aluminium alloy.
AS 4566	Mushroom head (BA and BSF).	Aluminium alloy.
AS 4569	Hexagon head, close tolerance shanks, cadmium plated all over (BA).	High tensile steel.
AS 4597	Round head, recessed head (BA and BSF).	High tensile steel.
AS 4598	Mushroom head, recessed head (BA and BSF).	High tensile steel.
AS 6760–6802, AS 6850–6892, AS 6895–6937, AS 6985–7027, AS 7171–7213, AS 7264–7306, AS 7033–7075, AS 7123–7165	Bolts (unified thread), round head with flat.	S106.

NOTE

The preceding tables show the overall dimensions of bolt and screw heads (up to 1·0 in. dia.) in common usage, and are arranged to enable the designer to ascertain quickly the clearances necessary to accommodate these heads. The tables are intended to be complementary to the comprehensive information issued by the British Standards Institution and the Society of British Aircraft Constructors, whose co-operation is acknowledged.

These tables do not list bolts and screws above 1·0 in. dia.—these larger ones are dealt with in the relevant Specification, to which reference should be made.

Data sheets relating to nuts and washers in common use will be included in future issues of *Engineering Materials and Design*, and we hope to make available, in the near future, bound copies of these sheets, together with the present one.


Hexagon
A (max.)
B (max.)
R (max.)
E (max.)
Raised Countersunk
M
Countersunk
B
B
A
Slotted
Recessed
Round
Raised Cheese
A
K
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Cheese
A
R
R
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A
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C
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Mushroom
A
R
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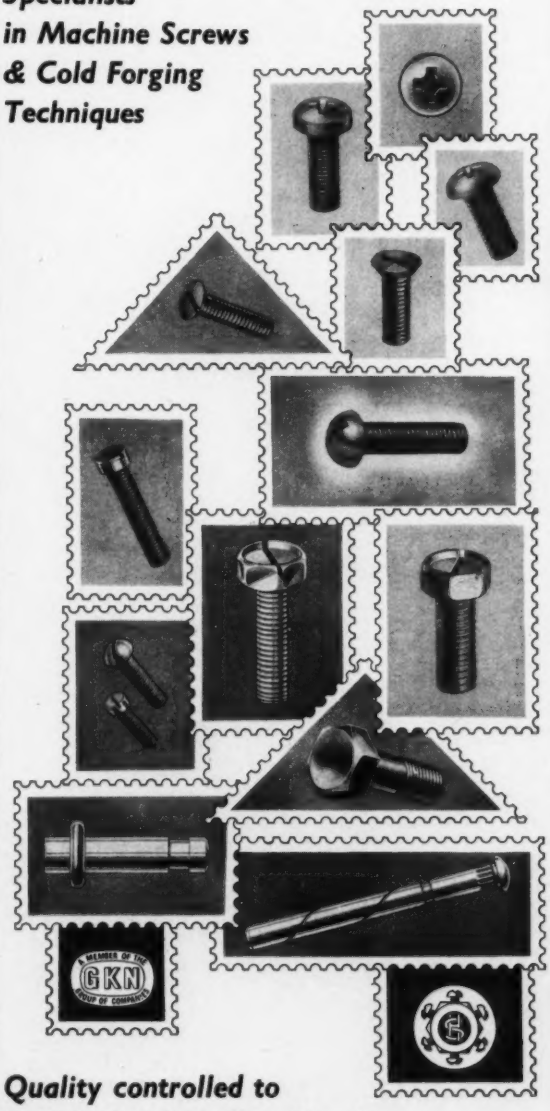

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New Books

Silicones. *Edited by S. Fordham.* (*George Newnes Ltd.—36s.*)

The volume under review can be divided into two parts, the first two chapters dealing with the basic chemistry of organosilicon compounds, the remainder of the book being devoted to aspects of their technology. It begins with a brief historical introduction, which should bear a message to British industry. One hopes that in future developments in inorganic and organo-metallic chemistry, where often a great deal of fundamental pioneering work is done in British universities, industry will not lag so far behind their competitors abroad.

The chapter on organosilicon compounds gives a brief précis of the vast amount of fundamental chemistry which is now known. Naturally, this cannot cover everything, and each reader will find omissions of some of his pet interests. The reviewer noted that the section dealing with silicon-hydrogen bonds was slightly out of date, as work in recent years has shown that silanes need not contain highly electro-negative groups attached to the silicon atom to enable them to add to multiple bonds, and, in addition, there are recent reports about an ionic type of mechanism of addition, as well as the better known free radical one. The interesting work of Fehér published about two years ago on polysilanes is also not mentioned. The reviewer disagrees with the statement on page 33 that the acetates and similar derivatives of silicon are better called silicon esters rather than alkoxysilanes. For many purposes, one can regard groups attached to silicon as behaving similarly to groups attached to a carbonyl function. Thus alkoxysilanes ought to be regarded as esters, and silicon acetates as mixed anhydrides. However, it would seem churlish to dwell on minor blemishes when the authors have succeeded in writing a most excellent summary of a vast and ever-growing field. The second chapter deals with some of the fundamental aspects; in particular, the physico-chemical properties of the polysiloxanes.

The remainder of the book deals with applied topics. One chapter discusses commercial aspects of the silicones, and this is followed by chapters on their manufacture and applications. These deal *inter alia* with silicone fluids, lubricants, rubbers and resins, electrical properties and applications of silicones, the conferment of water repellency on masonry, the treatment of textiles, as well as other miscellaneous uses. The book thus represents a very useful survey on what silicones can do for various industries, and should provide a stimulating introduction to this field for industrial scientists and technologists.

There is a pleasing continuity in the presentation of the present volume in that, although the subject-matter has been prepared by various experts, the book as a whole has been edited, moulded and re-written by Dr. Fordham, who must be congratulated on his task. The book contains eight plates and a subject index, as well as a list of useful references at the end of each chapter. It can be highly recommended to anybody who is interested in the subject of the silicones.

R. A. Shaw

Special Ceramics. *Edited by P. Popper.* (*Heywood & Co.—60s.*)

Over the last decade, or thereabouts, the rapid advance of materials technology has tended to outstrip the dissemination of the data which has been collected. Additionally, in many instances, numerous bodies and individuals have been progressing along similar paths with insufficient co-operation or exchange of ideas and information. During July, 1959, in an effort to remedy a situation such as this which had arisen in the ceramics industry, the British Ceramic Research Association held a symposium at which interested parties from both government and industry presented papers containing details of much of the recent research in this field. It is these papers which constitute the volume being considered. Together, they provide a concise picture of the present state of the art.

A number of the papers discuss the properties and preparation of materials such as silicon nitride, boron nitride, silicon carbide and calcium fluoride. Others deal at length with testing procedures which ascertain such properties as thermal conductivity, creep, permittivity and the effects of irradiation.

When a suitable material has been produced under laboratory conditions, it is no simple matter to find a suitable production technique, and fabrication presents many difficulties. For obvious reasons, ceramics do not lend themselves to machining processes, although grinding may be carried out on most of them. Much attention has been paid to these problems in recent years. Methods of preforming, particularly with those materials which are produced as powder-pressings, are discussed at length. For instance, it has been found that, in the case of silicon nitride pressings, it is possible to interpose a machining operation by breaking the sintering treatment into two separate stages.

Parallel with the compounding and fabrication problems are those of the accurate control of heat-treatments. Two papers consider the design of accurately controllable furnaces, both electric, but one incorporating a carbon tube element.

The search for materials which will withstand ever higher temperatures and increased rigours of service proceeds to keep pace with the increasing demands of, among others, nuclear, rocket, gas turbine and communications engineers. This book will help to show them what has and is being done, and what can be hoped for in the not-too-distant future.

R. B. Selwyn

Ultrasonics and its Industrial Applications. *By O. I. Babikov.* (*Consultants Bureau, New York—$9.75.*)

This book, the original Russian text of which was published in 1958, is a useful account of the industrial applications of ultrasound in the Soviet Union. The translation which has now been produced reads smoothly and has few serious mistranslations, but the illustrations are of poor quality and the lack of an index cannot be commended. On page 201 half a sentence has been omitted.

After a theoretical introduction dealing with the properties, propagation and absorption of ultrasound, ultrasonic generation is covered in a section which deals adequately with magnetostrictive and piezoelectric techniques. This section mentions very briefly jet generation methods, and the only equipment of this type illustrated is American. There are long and interesting sections devoted to pulse-transit-time and continuous wave absorption methods of ultrasonic flow detection. Shorter sections cover the use of these techniques to determine the grain size distribution and elastic properties of metals. Industrial applications such as the promotion of wood hydrolysis, the determination of the degree of deterioration of transformer oils, and the analysis of ternary methanol-ethanol-water mixtures are described. Ultrasonic drilling is well covered in a separate chapter, and there are short sections on the use of ultrasonic activation for the soldering of aluminium and the grain refinement of cast metals. Ultrasonic cleaning methods are described, and in this section ultrasonic smoke precipitators are advocated for industrial smokestacks.

From the bibliography and illustrations of equipment, one is made aware of the author's acquaintance with Western practice. This translation should therefore help Western scientists to attain a similar familiarity with the not inconsiderable Russian activity in this field, although in many respects the scope of Soviet use of ultrasonic techniques in industry appears to parallel that of the West.

D. J. Godfrey

Report on the Elevated Temperature Properties of Aluminium and Magnesium Alloys, *A.S.T.M. Special Publication No. 291.* (*American Society for Testing Materials—$7.00; members $5.60.*)

A unique, comprehensive and valuable collection of data summarising the properties of various alloys at elevated temperatures. They include wrought and cast aluminium and magnesium alloys of various compositions, including those containing 99·6 per cent pure aluminium. Short time values of tensile, creep and rupture at various temperatures makes this report of considerable value to engineers and designers.

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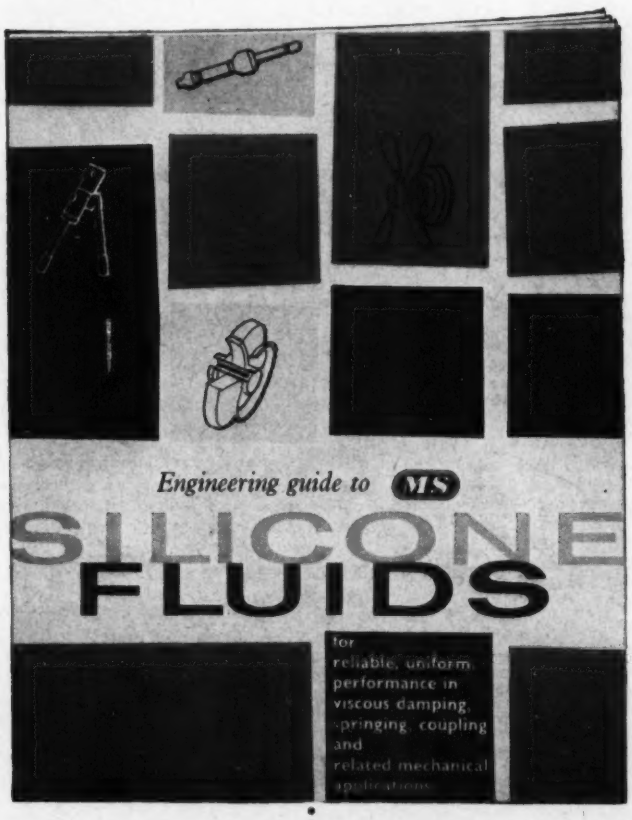

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New Books (cont. from page 386)

Modern Dielectric Materials. *Edited by J. B. Birks.* (*Heywood & Co. Ltd.—42s.*)

The first reaction to this book was that it was too short to cover adequately the wide field attempted; this is even more noticeable when an inspection of the index reveals that the coverage is not only of dielectric materials, but also, perhaps even mainly, of insulating materials. An introduction by the editor outlines the fundamental physics approach to dielectric constant, loss tangent, molecular properties of dielectrics, insulation resistance and dielectric breakdown. It then proceeds to deal with thermal, mechanical and other properties in approximately two pages.

The first chapter, on paper, deals adequately with its properties so far as cable and capacitor applications are concerned, but its use in power transformers is virtually ignored, which is hardly in accord with the respective consumption in these fields. As a result, no mention is made of the introduction in America of treated papers for which increased thermal endurance is claimed, nor of presspaper and pressboard which, while not strictly paper, are produced by basically similar processes. One would also have liked to see mention of asbestos and other heat-resisting papers, together with some guidance on the thermal endurance of the cellulosic papers dealt with.

Hydrocarbon insulating oils are also approached more from the needs of the capacitor and cable impregnator than from the more general electrical user, but the survey is well balanced. The treatment of chlorinated hydrocarbon impregnants in the following chapter has not so much bias, although it might have been preferable to avoid using the A.S.T.M. disc electrodes for measuring the electric strengths, as these are recognised as giving less differentiation than spheres.

Apart from terminology, the chapter on natural and synthetic rubbers was good, although it might have been improved by including guidance on the relative behaviour of the materials when exposed to the atmosphere, particularly in the tropics and other stringent conditions. To cover the whole range of plastics materials used as electrical insulation in some fifty pages shows considerable ability to select only pertinent matter. Some of the information included seems to have an unnecessary American bias, particularly the section dealing with phenolic laminates, where the grades are quoted from N.E.M.A. rather than B.S.I. documents. The absence of alkyd moulding materials is a little surprising, particularly as space has been found for aniline- and urea-formaldehyde. The treatment of silicone liquids, rubbers, surface coating and impregnating varnishes, bonding resins and compounds is as complete as can be expected in some twenty pages and the temptation to draw too heavily on American sources has been successfully avoided.

Remarkable condensation has also been achieved in the chapter on ceramics, where ceramic technology is outlined succinctly followed by brief entries on materials of high and low permittivity with mention of ferro-electric and piezo-electric materials; a section is included on the application of ceramics.

The chapter on glass covers information on composition, manufacture and the physical and electrical properties. The shortness of the chapter on mica and micanite is characteristic of omnibus books on insulation. The information provided covers the ground quite fully, although it does not mention mica papers, nor are they included in the chapter on paper. This chapter might also have been a convenient place to include information on the glass-bonded mica made by Mycalex. The final chapter on fibres and textiles seems to omit reference to woven fabrics and tapes; this is surprising in that, apart from wire coverers, these are of interest in the electrical industry. For anyone concerned with the properties of the yarns the information included is useful.

Although the specialist on any particular material will find this book inadequate, for someone wanting a general survey it is valuable, and it is hoped that the demand will be such that a new edition will enable Dr. Birks to expand the present one.

W. H. Devenish

OTHER BOOKS RECEIVED

The Story of the Saw. *By P. d'A. Jones and E. N. Simons.* (*Newman Nearne Ltd.—21s.*)

A well-illustrated survey covering the evolution of the saw from prehistoric times to the highly specialised machine tools of today. The source of information is world wide, and commemorates the bicentenary of Spear Jackson Ltd.

Newnes Engineer's Reference Book, *9th edition. Revised by A. T. Collins* (*George Newnes Ltd.—£5.*)

Containing over 2,000 pages, this exhaustive reference book needs no introduction, the latest edition containing new sections on jig grinding and wood screws. Data on welding and electroplating has been considerably extended, and the entire subject-matter has been brought up to date, numerous tables being added to extend the usefulness of this volume. The index contains fully cross-referenced entries.

Finishing Handbook and Directory, *1961 edition.* (*Sawell Publications Ltd.—37s. 6d.*)

In this edition the alphabetical guide to finishing has been enlarged and several conversion tables included. The directory of firms has been extended to include the widening activities of many companies, and the general layout and presentation of the comprehensive data make this a valuable reference book. One would have thought, however, that the section on wood finish in the 1960 edition was worthy of retaining and enlarging rather than being deleted from the new edition.

The Engineer Buyer's Guide, *1961.* (*The Engineer—10s.*)

The contents of this latest edition follows the pattern of previous years, entries being confined to firms advertising in *The Engineer* or the *Buyer's Guide* itself. Some 2,700 classified headings are listed with appropriate cross-references.

A.S.T.M. Standards on Petroleum Products and Lubricants, *Vol. 1—Methods of Testing, Specifications, Definitions, Charts and Tables.* (*American Society for Testing Materials—$9.50; members $7.60.*)

Contains 168 standards, including over 30 new ones, applicable to crude petroleum, butadiene, motor and aviation fuels, cutting oils, greases and other related materials.

1959 Supplement to the Bibliography and Abstracts on Electrical Contacts, *Special Technical Publication No. 56-N.* (*American Society for Testing Materials—$3.50; members $2.80.*)

Contains references to papers and reports dealing with the design of electrical contacts, and the materials used.

Selected Papers on Stress Analysis. (*Chapman & Hall—50s.*)

A selection of international papers in their original language presented at the Institute of Physics' stress analysis group conference in Delft, 1959. The selected papers are published in full, with abstracts in English, French and German, the main theme being methods of stress analysis and their application.

Swedish Aeronautical Research on Metallic Honeycomb Sandwich Construction. *By Bryan R. Noton.* (*Aeronautical Research Institute (F.F.A.) of Sweden.*)

Published lecture originally presented in the U.S.A. Contains a multitude of test results concerning metallic honeycomb. The bibliography covers forty-five publications on Swedish research.

Performance of Taps (Report No. 42). (*Production Engineering Research Association—7s. 6d. to non-members.*)

This booklet contains an account of an investigation designed to compare the shape and performance of nominally similar taps, and to determine the effect of rake and flute area on tap performance when tapping low carbon steel En 3B. Marked differences in performance were found, and recommendations are made on those factors most likely to influence performance.

LETTERS TO THE EDITOR

Design Costs

Sir,

You may have come across the phrase now currently being applied in America, "Value Engineering and Analysis". This has only become a subject for study, so to speak, during the last few years, and though there is nothing new in the process as such it is not being sufficiently applied as an overall weapon to reduce costs. What it really comes down to, in a few words, is this: How can one make one's design offices, planning and purchasing departments sufficiently cost-conscious to ensure that by the time the design is finalised it will lead to the most economical production costs? Naturally, it goes without saying that once a bad design has gone through for production there is little the latter can do to make up for the mistakes of the designer.

My problem is how to make ordinary members of the drawing office cost-conscious, and I am endeavouring to collect every bit of published information towards this end.

The sort of material I have at present emanates chiefly from America, and relates to the better known aspects, such as the cost of tolerancing and surface finish, where it is so easy for the draughtsman to err on the right side to make sure —and up goes the cost.

I would be glad if you could help me obtain detailed information relating to and giving details of the cost involved in different aspects of engineering design. This is a broad bracket, but many examples could be given in this field to assist the designer and/or draughtsman to produce the most economic design, and generally to augment his probably meagre knowledge of the cost of what he is drawing.

P. D. Scott Maxwell

Cooke, Troughton & Simms Ltd.,
Haxby Road,
Yorks.

Design and Function

Sir,

The neglect of the design processes, both in the education of technicians and in industry itself has long been a big problem, and may well become a major disaster for British industry. Britain seems to be unique among modern industrial nations in making what amounts to a fetish of this neglect.

In its real sense the term design covers both the technological and the æsthetic aspects of the product. Recently, however, it has come to be used to describe the purely æsthetic qualities of the product, even in the engineering industry, where the functional aspects of the machine are the vital and sometimes the only consideration. Two effects have followed from this. Form and shape tend to be grafted on to a machine by what is called an industrial designer, and now a further contributor who calls himself an ergonomicist has appeared on the scene, who claims as his function the relation of the machine to the man.

It will be apparent that ideally the appearance of a machine arises from the function of the machine. The measure of the success obtained from extracting and using favourable æsthetic aspects of the basic form is a measure of the talent of the engineer or designer. With the growth of industrialisation and its passion for ever smaller divisions of responsibility, the whole purpose of design has become obscured, and today we are in danger of becoming tolerant of these unhappy marriages of "stylist" and technologist. However necessary this process might be in the special circumstances of today, it should be recognised that in any rational society this solution is an expedient from which we should aim to escape at the earliest possible moment. Similarly with ergonomics. An engineering designer who designs a machine which a man can't operate with comfort and safety is a bad designer and engineer. It is as simple as that. This is not to say that there isn't scope for seeking the advice of medical and other people who have specialist knowledge on the behaviour of the human body in particular circumstances; for example, in high-altitude planes. However, it is ludicrous to invent a new specialist or ergonomicist in order to perform a function which is an inseparable part of the engineer's or designer's work. It is cheaper and more satisfactory to ensure that the engineer or designer does his job correctly.

To take as an illustration a case which the average person may encounter any day of the week, the express electric train service which runs from Victoria to Chatham and beyond is rapidly becoming famous for its unpleasant shudder and motion along the track. Having travelled in many parts of Europe and America by train, I rate this train ride one of the most disagreeable to be found. This must be something to do with the transmission, the suspension, the coach geometry, either individually or in combination, and as such it may fairly be termed an engineering problem. Taken as an engineering problem without relation to the experiences of similar trains abroad or in this country, the complexity of the analysis of such a problem must be extremely high. However, the complexity of the analysis should not blind us to two major considerations. Other countries have in operation high-speed electric trains on narrow tracks which are comfortable, and secondly, mathematical analysis is not the only means of arriving at truth. Ricardo once said that when in the course of his engine experiments he arrived at an impasse he then "tried every bottle on the shelf". Those who have been in this situation will know that this does not mean clutching at straws, but rather a method of introducing an observable element of change into the problem, even if that change temporarily aggravates the condition. One would be happier as a traveller if one could see some evidence of intense experimentation on this line in order to get such information. Even in the technical press one sees little treatment of the subject, and certainly no invitation to the technical readership to contribute its views (see *E.M. & D.*, March 1961, p. 147—Editor).

So much for the ride and technology. What about the brave new buffet cars and their promise of egalitarian service to the travelling public? Well, on this particular line you will rarely find any of the regular travellers in the buffet cars, and for many good reasons. The most obvious of these is a consequence of the rough-riding properties of the coaches. That is to say, there are purely mechanical difficulties in consuming what you have bought. Travelling east from Victoria, for example, all of the table contents move rapidly to the north and remain there. The coffee you have bought quite quickly fills the saucer and ends up all over the table. This is not, let it be understood, an isolated occurrence, but one which one can observe every time one travels on this line. This operation of the coffee leaving the cup is performed with some precision, and the solution of British Railways to this is equally precise—no less than a specially designed plastics disc which is placed on the cup in order to retain its contents. On the first (and subsequent) occasions when I used these I poured the hot coffee into the cup and placed the disc. In a short interval of a few minutes, during which time cold blasts of wind from swinging doors had cooled the cup, a powerful vacuum formed which secured the disc to the cup with the tenacity of a limpet. In the struggle to free the cap some of the coffee disappeared up my sleeve and the remainder on the floor. A slight discontinuity around the rim or a tiny hole in the disc would have been sufficient to cure this elementary problem.

It serves no purpose to try to identify the source of this type of failure in design, but running right through there appears a detectable arrogance and lack of concern with the final result which one tends to associate with committees.

These are questions not merely for British Railways but for all of British industry, both private and public. The means and the talent are here beyond doubt, but somewhere along the line of industrialisation we have allowed the indivisible processes of design and function to become so obscured that our products rarely benefit from the feed back of use and operation. The problem is by now complex and may even be insoluble, but it is certain that only when technological design is recognised to be an intellectual activity of a high order will the necessary progress occur. In engineering design all is not analysis, and in æsthetic design all is not art.

Other countries are recognising this, and attempting to ensure that in their technical education detail is not regarded as inferior to the general. We must do the same, otherwise, capital investment or no capital investment, our exports are for the high jump.

H. Masheder

54 Platts Lane,
Hampstead, London, N.W.3.

EMD 6667 for further information

too weighty to stop!

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Interesting Exhibits at the INTERNATIONAL REFRIGERATION & AIR CONDITIONING EXHIBITION

EARLS COURT · LONDON · APRIL 11 to 14 · 1961

Closed-cell Insulation

Plasticell is a constructional, insulating and reinforcing material manufactured from expanded polyvinyl chloride (p.v.c.). Available in densities ranging from 2·5 to 6·25 lb./cu. ft., this material is claimed to be resistant to chemical attack, to have excellent thermal (K factor approximately 0·2 B.t.u./in./hr./sq. ft. deg. F.) and electrical properties, to be extremely resistant to ageing, and not to support combustion. One hundred per cent closed-cell construction is said to give this material unique characteristics compared with other plastics foams—including superior moisture and gas vapour permeability resistance, a built-in vapour seal, and high mechanical strength.

Sandwich panels in p.v.c., glass resin, aluminium, laminated plastics and wood veneers, using Plasticell as an interlayer, are being used for dashboard panels for the motor industry, and for sections of air-conditioning ducting. *Microcell Ltd.*, 9 Kingsway, London, W.C.2.

EMD 6751 for further information

Sealing Compounds and Strip

M.R.S. 108 is a compound that has been specially designed for the refrigerator manufacturer who requires a handling grade of mastic. It is off-white in colour, has good adhesion to most surfaces, and is said to be sufficiently incombustible to prevent the spread of flame. The temperature limits of this material are claimed to be −40 to 80 deg. C., and the stability to be such that it does not skin or harden, but retains its original consistency indefinitely.

A gun grade of this compound is also available, known as type M.R.S. 114.

A sealing strip, M.R.S. 113, from the same firm, has a synthetic rubber base, and is claimed not to harden or dry out. Its main function is to provide a dust-proof, waterproof, gasket-type seal, and it is used only in compression-type joints. Although intended primarily for refrigerator manufacture, this material has uses in other industries. An interesting feature is that it can be over-painted with most paints, including stoving enamels. *Evomastics Ltd.*, Stafford.

EMD 6752 for further information

Chlorofluorocarbon Refrigerants

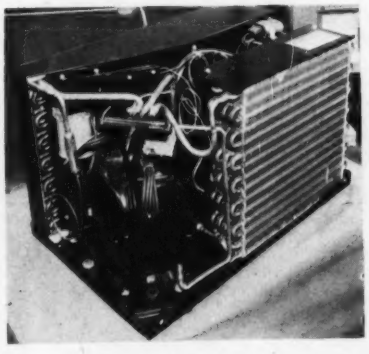
Isceon refrigerants can be used for every type of duty, from household refrigeration to large-scale air conditioning, and for producing temperatures below −130 deg. C. They are said to be safe to use, and to be non-flammable at ordinary temperatures; their vapours are non-irritant, non-toxic and harmless in contact with products ranging from foodstuffs to furs. These refrigerants are also claimed to have remarkably high thermal and chemical stability, since they can be used under normal operating conditions in contact with steel, tin, aluminium, copper, brass, lead and many plastics.

Another product, Isceon 11, is used in the preparation of foamed plastics or polyurethane foams. Foamed plastics are employed extensively in services where heat insulation is an important, if not the principal requirement. The use of Isceon 11 in place of carbon dioxide is claimed to increase insulation by 50 per cent. This permits significant saving of insulation space, and consequently of the insulating medium itself. For example, the thickness of laminates and sheets may be reduced in proportion to the drop in thermal conductivity. *Consolidated Zinc Corporation (Sales) Ltd.*, 37 Dover Street, W.1.

EMD 6753 for further information

Reverse Cycle Unit

The 1 h.p. Chrysler Airtemp room unit is designed to operate on the reverse cycle principle, which means that it is capable



of either heating or cooling, depending on the requirement of the user.

The reverse cycle principle is popular not only because of its dual function, but also because the heat output which it provides is some 20 per cent more than the electrical input. The method of operation is based upon the utilisation of the heat that is normally dissipated to the atmosphere through the condenser. This heat is brought into the operative space through filters, thereby enabling the unit to serve a dual purpose. A comprehensive selection of these units, ranging from 1 to 2½ h.p., is available. *Chrysler Airtemp Ltd.*, 68 Knightsbridge, S.W.1.

EMD 6754 for further information

Air Conditioners

The Whispair "packaged" air conditioner is specially designed for installation in commercial premises. Its "slim-line" construction—height 30 in., width 33 in. and depth 10 in.—and two-tone finish enable it to blend unobtrusively with modern office *décor*. It can be fitted to any outside wall over 3 in. thick (the vent is only 32 × 16¼ in.) and does not project beyond the building line. The pre-eminent feature of the Whispair is its silence, ensured by absorbent acoustic insulation and a unique twin-drum circulation fan assembly. Air- or water-cooled models are available. Six four-way adjustable grilles give draughtless air distribution through 360°, and a thermostatically controlled 2 kW. heating element is fitted for use when required. The unit has a nominal capacity of 1 ton refrigeration (12,000 B.t.u/hr.) in maximum tropical conditions.

Also available are the Temkon Series N room air conditioners, in three basic models—the N.468 three-phase, the N.422 single-phase, and the N.303 single-phase. These units are supplied with either air-cooled or water-cooled condensers, and can be obtained for cooling only, or cooling plus heat pump, or cooling plus electric heating. *Temperature Ltd.*, Burlington Road, London, S.W.6.

EMD 6755 for further information

Thermoelectric Cooling

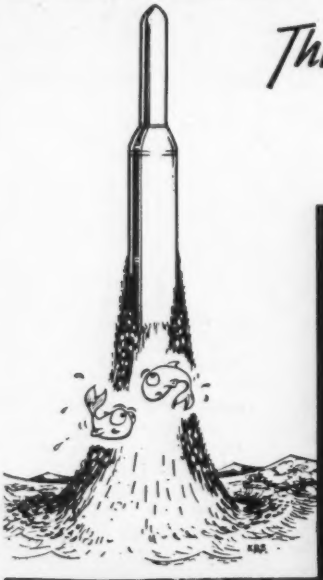
Frigistors are semiconductor thermocouples which perform the function of refrigerators and heat pumps. They are fed by d.c. from a battery, or from a rectifier power-pack connected to the mains. In the latter case the ripple should not exceed 10 per cent, although no smoothing is required when the performance is not critical. Standard Frigistors are designed to work at currents from a few to around 20 amps. Depending on the number of couples connected in series, the voltages will range from a fraction to 12 V. and more.

In its present state of development, thermoelectric cooling and heating is said to be already beginning to compete with conventional refrigerators and heat pumps in medium and large-scale applications, while it has filled a gap in small-scale applications where no similar means have hitherto existed.

A drinks cabinet, an immersion cooler and also electronic applications of Frigistors were on show. *Semiconductor Thermoelements Ltd.*, 207 Brondesbury Park, London, N.W.2.

EMD 6756 for further information

EMD 6668 for further information



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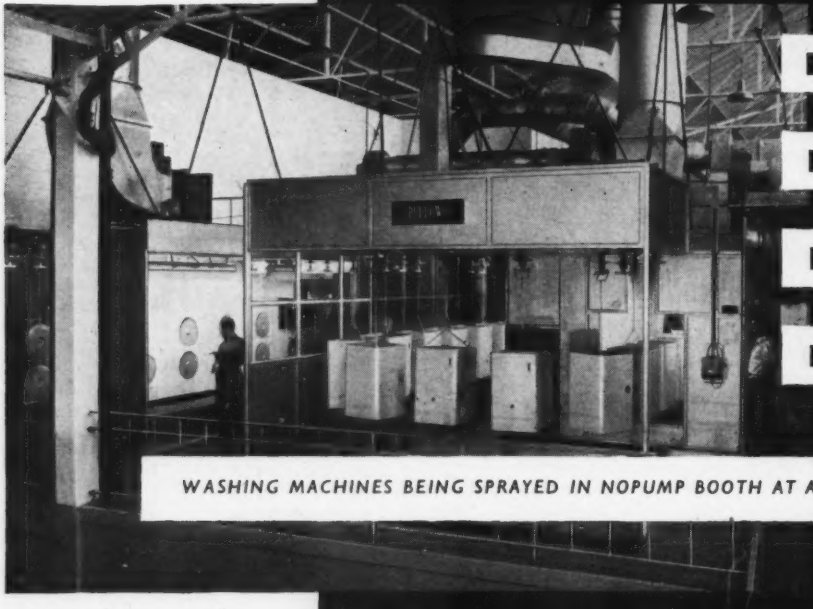
In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.



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WHAT'S NEW IN MATERIALS

Paste for joining Aluminium Alloys

A new paste compound, AutoChemic 990, represents a completely new development for joining nearly all aluminium alloys, giving high strength (9 tons shear strength) deposits requiring no finishing. Recommended for wire joining and other fine work, this chemically complex compound, when heated, produces a series of chain reactions terminating in metallic reduction at 400 deg. C. The compound can be applied by brush, spatula, or by dipping, and facilitates pre-placement for continuous production of complicated assemblies using brazing ovens. This new addition to Eutectic's range of paste compounds means that most common metals can now be joined using this technique.

Neu-Tec-Tronic 157 BN is a new solder-type alloy containing a non-corrosive neutral flux core designed especially for electronics applications. The deposit has rapid solidification with 50 per cent better electrical conductivity than 50/50 solder, and will accept a wide range of metallic platings. *Eutectic Welding Alloys Co. Ltd.*, North Feltham Trading Estate, Faggs Road, Feltham, Middlesex.

EMD 6757 for further information

High-temperature Thermocouples

A range of high-temperature thermocouples incorporating non-metallic materials is under development. The couples are especially interesting when temperature measurement is required under strongly reducing conditions (for example, in contact with graphite), or when a high output is useful. Individual calibration is necessary at the present stage of development.

Silicon carbide/silicon carbide thermocouples are made from N-type silicon carbide against P-type silicon carbide, and are said to give high output (around 175 μV/ deg. C.). They can be used continuously at temperatures up to 1,500 deg. C. or for short periods up to about 1,900 deg. C.

Silicon carbide/graphite thermocouples have a high output (around 200 μV/deg. C.) and fairly low resistance. They can be used over the same temperature range as all-silicon carbide couples.

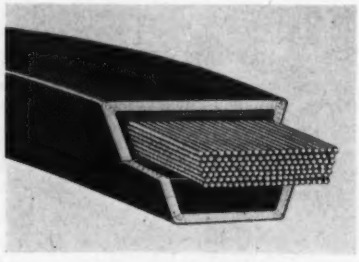
All-graphite thermocouples are made from two different types of graphite, and are air insulated so that they can be used at over 2,000 deg. C. in non-oxidising atmospheres. Output voltage is moderate, but compares favourably with that from high-temperature metal thermocouples.

Graphite/metal thermocouples can be produced using graphite as one element and a refractory metal as the other. Satisfactory couples have been made from graphite/tungsten and graphite/tungsten-rhenium alloy. The operating temperature is limited by the insulation employed, i.e. alumina can be used up to 1,600 deg. C., or thoria to about 1,800 deg. C. *Morgan Crucible Co. Ltd.*, Battersea Church Road, London, S.W.11.

EMD 6758 for further information

New Range of V-Belts

Longer life, coupled with higher efficiency, is claimed to be possible with a new range of V-belts having higher horse-power ratings. The two new belts being introduced are the Green Seal E.C. Red V-belt, claimed to be dimensionally stable under all stocking conditions, with a 40 per cent higher horse-power rating



than the old standard E.C. V-belts at no extra cost; and the Green Seal HY-T Premium V-belt, having a 100 per cent higher horse-power rating than the old E.C. V-belt at 25 per cent extra cost. This latter belt is said to be static conducting, oil-resisting and dimensionally stable under all stocking conditions. *The Goodyear Tyre & Rubber Co. (Great Britain) Ltd.*, Wolverhampton, Staffs.

EMD 6759 for further information

Heat-resistant Conveyor Belting

Terylene reinforced Thermo-Flo heat-resistant conveyor belting (Spec. 272 and 124), which is a premium grade hot-materials conveyor with similar properties to the cotton reinforced Thermo-Flo conveyor, is available with two types of carcass reinforcement: TD.90, which will rate at 90 lb. per ply in. for vulcanised joints and 50 lb. per ply in. for mechanical fasteners; and TD.112, which will rate at 112 lb. per ply in. for vulcanised joints and 54 lb. per ply in. for mechanical fasteners. The belt is available in widths and plies as required for the various conditions of service.

Thermo-Flo Terylene will handle hot, fine slumping materials, and is specially suitable for the higher temperatures up to 205 deg. C., where the superior heat resistance of Terylene over cotton helps to prolong belt life. It can be made endless by vulcanised joints, either in the factory or on site by the firm's mobile field splicing service. *The Goodyear Tyre & Rubber Co. (Great Britain) Ltd.*, Wolverhampton, Staffs.

EMD 6760 for further information

General-purpose Rubber

A new intermediate viscosity rubber masterbatch which combines synthetic rubber and a reinforcing resin has been introduced by the Chemical Division of the Goodyear Tire & Rubber Co., of the U.S.A. Called Plioflex 224, the new rubber exhibits good hardness and stiffness characteristics, and has excellent abrasion and tear resistance, tensile strength and mould flow properties.

The present-day trend is toward lower viscosity rubbers, and to obtain maximum advantage from a high styrene reinforcing resin, it must be thoroughly dispersed in the rubber. Goodyear claim to have solved this problem by blending Pliolite resin latex into Plioflex rubber latex, and coagulating the two together in a carefully controlled process. The resulting masterbatch is said to process easily, both on mills and Banbury mixers.

The new rubber is also produced in a free-flowing crumb form that is packaged in Kraft paper bags. This product handles easily, and does not become compacted during storage. *Hubron Sales Ltd.*, Failsworth, Manchester.

EMD 6761 for further information

Extended-surface Tubing

Composite corrosion-resistant helically gilled tubing (in which the gills are integral with the base tube) is now being produced out of mild and stainless steel; zirconium and titanium; pure and alloyed aluminium; magnesium and copper. Tube sizes range from $\frac{1}{8}$ in. dia. at the root of the gill up to 6 in. overall outside diameter, with wall thicknesses from 18 to 6 s.w.g.

The gill forming process, which provides good heat transfer and strength properties, is a comparatively new departure in tube manipulation. The tubes can be bent without risk of deformation, and bending radii applied to plain tubes need be only slightly increased for gilled tubes of equivalent root diameter. Gills may also be removed from parts of a tube to facilitate bending, as, for example,

in the case of high-gilled fine pitch non-ferrous tubing.

Lengths up to 21 ft. can at present be produced, and the tubes can if necessary be ovalled after forming, in some cases to a ratio of as much as 3:1 between the two axes. They can be supplied as-formed, annealed, normalised or in any other heat-treated condition according to the material of which they are made. They can also be provided with different shaped ends, and can be pressure tested up to 5,000 p.s.i. *Accles & Pollock Ltd.*, Oldbury, Birmingham.

EMD 6762 for further information

FEROBESTOS SWINGS INTO ACTION AT BRITAIN'S MAJOR PORTS

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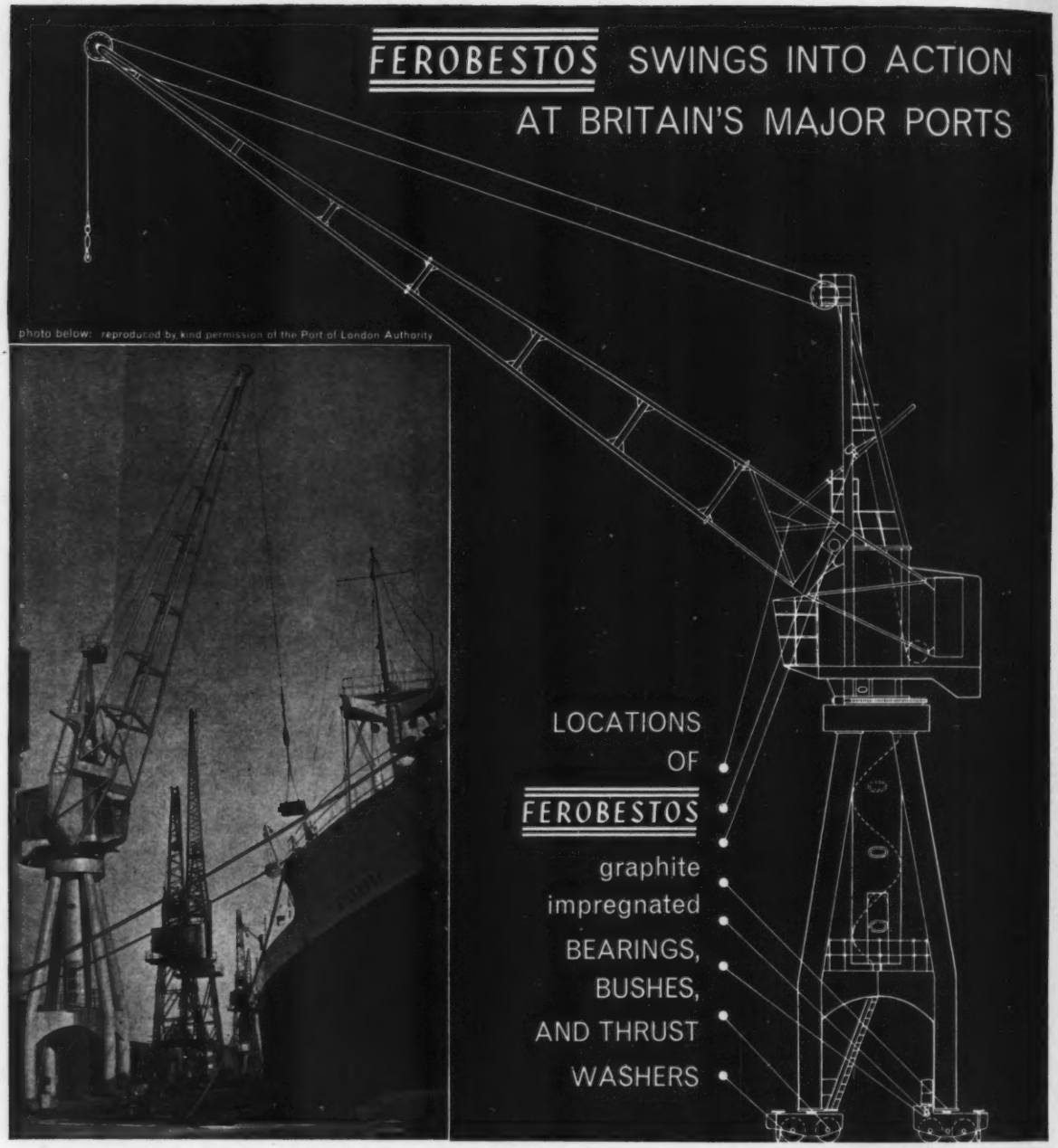

AS MODERN AS ITS USES . . .

Fitting of Ferobestos asbestos reinforced plastics on the new Stothert & Pitt dockside crane is yet another example of the way in which forward-thinking engineers are specifying this modern material for their most challenging and exacting projects.

This remarkable crane, lifting 5 tons at 80 ft radius or 6 tons at 70 ft radius incorporates Ferobestos bushes, bearings and thrust washers. A low coefficient of friction being essential, Ferobestos grade LA 3 material was used. This is a general purpose material laminated from asbestos cloth impregnated with phenolic resin, and including colloidal graphite to assist lubrication.

In such applications the performance of Ferobestos—an engineering material in its own right, NOT a substitute—is superior to that of conventional metal bearings.

The Stothert & Pitt DD2 Cargo Crane uses Ferobestos material in the positions indicated on the diagrammatic drawing.

FEROBESTOS

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JW244

WHAT'S NEW IN COMPONENTS

Switching Panel

The switching panel type MR527 has been designed to replace the F.M. switching panel type MR517 in the Southern F.M. system for the display and measurement of transient physical phenomena on an oscillograph. The oscillator type M785 is being designed for use with this new panel.

Up to four oscillators, each of which is controlled by a single capacitance or inductance type transducer, may be connected to the MR527. This arrangement permits the recording system to be located very much farther from the apparatus under test than was previously possible.

Controls are provided for reversal of signal polarity and variation of output amplitude for each channel independently. This facilitates immediate switching of any transducer output into the pre-amplifier type MR513 without resetting the controls. Provision is made for the insertion of degree marker pulses, the polarity of which is also preset for each channel. *Southern Instruments Ltd.*, Frimley Road, Camberley, Surrey.

EMD 6763 for further information

Transducer Fluid Depth Gauge

The Transdeptor is a depth gauge relying for its basic accuracy upon a highly sensitive and stable pressure transducer. This transducer, which has no moving parts, translates the applied pressure into an alternating current signal of which the frequency bears a precise relationship to the pressure. This technique of depth determination offers the following advantages: (a) the signal may be transmitted over great distances by means of a two-wire system without any loss of measuring accuracy, (b) the electrical characteristics of the transmission line are not important, since the information is contained in the frequency of the transmitted signal; (c) the transducer contains no springs, pivots and mechanical linkages (which are susceptible to failures); and (d) the gauge may be left unattended in remote locations for long periods of time without the need for maintenance.

The pressure-sensing element is a Solartron pressure transducer type NT4-980. This transducer consists of a thin-walled metal cylinder which is maintained in vibration electromagnetically. An increase in the pressure on the external surface of the cylinder introduces a hoop stress which causes the natural frequency of vibration to be reduced. A measure of system frequency is thus a measure of the applied pressure. The unit may be compared hypothetically with an electronically maintained tuning fork, the stiffness of which is a function of an applied force. The cylinder is manufactured from an isolastic material, and thus changes in ambient temperature have a very small effect upon the overall accuracy. *Solartron Electronic Group Ltd.*, Farnborough.

EMD 6764 for further information

Standard Reference Voltage Source

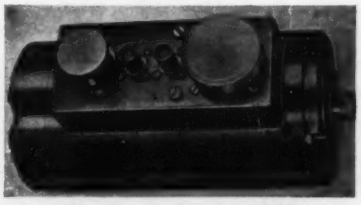
The Convolt is a self-contained unit, for inclusion in other equipment, which when connected to a supply of nominal value 115 or 230 V., 50 c/s, single phase, will give an output of approximately 1 V. d.c. with stability comparable with that of a standard cell. A model is available for operation from 28 V. d.c.

The unit is suitable for energising the potentiometer circuit of millivolt recorders, and similar applications where the stability required is associated with an ability to draw a larger current than is obtainable from a standard cell. *Communications (Air) Ltd.*, Half Moon Street, Bagshot, Surrey.

EMD 6765 for further information

Angle Encoding System

BEL-5 is a new, high-precision angle encoding system which divides a single shaft revolution into 360,000 parts, and simultaneously provides parallel real-time read-outs in three forms: electrical 8-4-2-1 binary coded decimal, electrical straight decimal and visual decimal on neon number tubes. Other systems avail-



able provide pure binary resolutions of from 2^{18} to 2^{21} in a single turn.

The total weight of the system, which can be used for airborne use since it fulfils the requirements of MIL E-5400, is only 140 lb., the power requirements being 650 W. *Ketay Ltd.*, Eddes House, Eastern Avenue West, Romford, Essex.

EMD 6766 for further information

New Starter

The DOC.80 is a new 5 h.p. starter for three- and single-phase motors. It is claimed to be the lowest-priced unit on the market giving single-phasing protection on three-phase supplies. An ambient temperature compensator is incorporated to allow for differences in local temperature between the starter and the motor. A set of overload heaters is supplied separately in a small pack. There are fifteen different heater ratings, and the starters are supplied fitted with any one of five coils covering standard voltages.

The DOC.80 can be easily mounted into position, three-point fixing being carried out from inside the case without having to remove any component. Wiring is also simple, and leads can be taken in and out of the starter from the top, bottom or side. *Associated Electrical Industries Ltd.*, Motor and Control Gear Division, Industrial Control Gear Sales, Marsden Mill,, Nelson, Lancs.

EMD 6767 for further information

Load-sensing Governor

A new electric load-sensing governor has now been developed to give very accurate control of alternator sets where any alteration in frequency under varying load conditions must be kept to a minimum. The governor operates by continuously measuring the electrical load, and positions the throttle according to this signal before the engine has had time to change speed. The main signal to the throttle actuator, being directly proportional to the alternator output, requires a second signal proportional to the error in speed to trim the throttle setting to restore the engine to its set speed if any deviation does take place. No drive from the prime-mover is required when using this governor. *Ardleigh Engineering Ltd.*, Standard Ironworks, Port Lane, Colchester, Essex.

EMD 6768 for further information

Photo-electric Alarm for Continuous Processes

A photo-electric device which will give warning of the slowing down or stoppage of machinery used in continuous processes is now being produced. This device, which can sense changes in rotation and other movement, is particularly useful where machinery is left unattended, and can monitor many types of machinery including conveyors, rotating shafts, fans, rollers, press rolls, reciprocating shafts, levers and crank arms. The unit is dust-tight for use in industrial conditions.

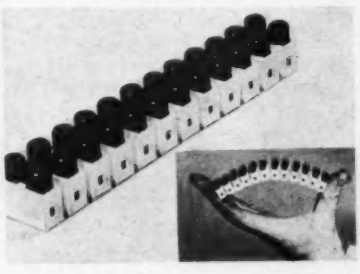
The device is operated by repeated regular interruptions of a light beam which maintain a relay energised. Should the interruptions fall below a predetermined speed or stop with the light beam broken or unbroken, the relay will give an alarm or initiate correction. Magnetic, as well as photo-electric, sensing heads are also available. *Hird-Brown Ltd.*, 244 Marsland Road, Sale, Cheshire.

EMD 6769 for further information

Flexible Spring-loaded Terminal Blocks

A new flexible terminal block manufactured in p.v.c. has been added to the Suprafix range. This new block, rated at 10 A. and working up to 500 V., has been designed for use with the standard range of Hellermann terminals, which are claimed to obviate the use of solder or pinch screws, and which are designed to provide a quick and reliable method of termination. *Hellermann Ltd.*, Crawley, Sussex.

EMD 6770 for further information



WHAT'S NEW IN COMPONENTS

One-piece Double-acting Fluid Seal

A fluid seal of symmetrical cross-section, for use in double-acting cylinders, is announced. It consists of two U-rings of equal size made from cotton or nylon fabric; these are bonded with a soft rubber filler to form a seal with inner and outer faces that are slightly convex. Distortion is said to be impossible, because there is no part where fluid might be

trapped. The seal is supplied to fit pistons ranging from 1-7 in. dia. *Hall & Hall Ltd.*, Oldfield Works, Hampton, Middlesex.

EMD 6771 for further information

Electro-mechanical Valve

A motor-operated stop valve which can also be used to regulate the flow of fluids has been released. This valve, which varies in size from 3-10 in. dia., has a maximum working pressure of 550 p.s.i.g., and can also be manually operated by an override mechanism. The motor is reversible, has a maximum torque of 170 lb. in., and requires a starting current of up to 4 amps.

The electro-mechanical valve opens and closes according to the direction of rotation of a screwed spindle, which is operated by an actuator geared to a shaft speed of 25 r.p.m. Motivated by this actuator, the spindle engages a split nut and opens and closes the valve as it moves upwards or downwards. The speed of opening is 1 in. travel in 15 sec. at constant 400 volts.

Lowering of the spindle compresses and thus loads a spring; raising the spindle takes the load off the spring. In the event of an electrical failure, an isolating switch automatically disengages the split nut from the screwed spindle. If the spindle is in the lowered position, the spring returns it to the raised position and the valve is opened or closed accordingly, depending on the type of valve seats fitted. On renewal of electrical supply, the weather- and dust-proof actuator will function in the normal manner without adjustment.

Fully open and closed positions of the valve are limited by flame-proofed microswitches actuated by a flange on the spindle shaft. The split nut is held in engagement with the screwed spindle by a continuously rated solenoid energised by the electrical supply to a maximum stroke of 1½ in. The solenoid is in series with the motor, and when energised brings about the "shut down" in 0·1 sec. A special safety overload switch operates if either of the two limit switches fails to stop the motor.

As a flow regulating valve, a position indicator is employed to give electrical signals which can be translated into fluid flow. These signals are returned to the actuator, and can open or close the valve from any intermediate position. *I.V. Pressure Controllers Ltd.*, Atlas House, 683 London Road, Isleworth, Middlesex.

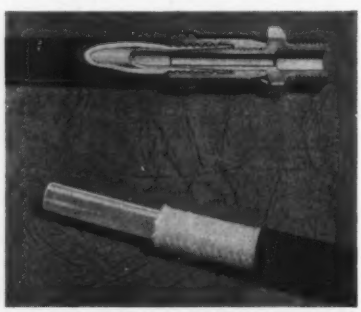
EMD 6772 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

High-pressure Nylon Hose

Nylon Fullway high-pressure hose, which is said to be light, strong and durable, and to have excellent chemical-resistant properties, is now available in bore sizes ranging from $\frac{3}{16}$-½ in. A suitable range of re-usable end fittings has been introduced for use with the hose, the smallest passage through each fitting being only a little less than the nominal inside diameter of the hose. It is claimed that, for a given size of hose, a much better



flow rate is therefore assured or, conversely, for any given flow rate required, a more compact installation is possible. *Tecalemit Ltd.*, Plymouth, Devon.

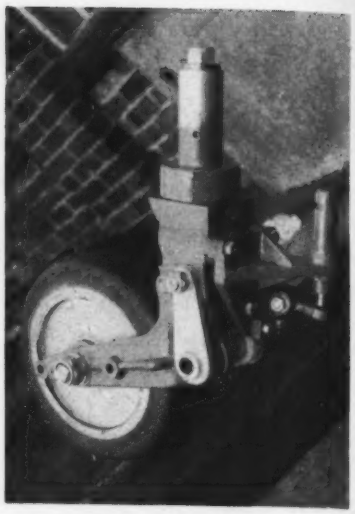
EMD 6773 for further information

Coloured Measuring Instruments

A feature of the 38 CY series of electrical measuring instruments is the availability of colour for the lower section of the instrument cover. Besides the standard black, single instruments can be supplied in a range of colours, or bulk quantities in any colour, to customer's specification. This means that the crystal range, as it is known, can be made to match in with instrument panels, or if required all voltmeters can be distinguished by one colour and ammeters by another.

The dials have been designed to give clear viewing from 4½ ft. Three types of movement are available: moving coil d.c.; moving coil a.c. rectifier; and moving iron a.c./d.c. *Measuring Instruments (Pullin) Ltd.*, Electrin Works, Winchester Street, London, W.3.

EMD 6774 for further information



Castor with Torsion Bar Springing

A new type of castor incorporates a turned iron spring with a mechanically operated expanding brake which is applied through an Ackerman bar connection. The castors are used in pairs, each castor having a dynamic floating capacity of 1,000 lb.

The castings used in the construction are of special high-duty aluminum alloy, fully A.I.D. approved, and the bearings in the hub of the wheel and in the shank fittings of the swivelling element of the castor are of the precision tapered roller type. The castor wheels are solid rubber tyred, and are 10 in. dia. *Autoset (Productions) Ltd.*, 69-73 Stour Street, Birmingham, 18.

EMD 6775 for further information

Electrical Air Filter

The new Industrion electrical air filter is of much sturdier construction than its predecessor, the Trion electronic air filter. The collecting cell is now fabricated from a heavier gauge aluminium, and the supporting framework and ionising section support bar have been strengthened. Another advantage claimed is that the insulators are now positioned out of the main air stream—this facilitates cleaning, and ensures greater reliability.

The associated electrical equipment has also been improved, and there are now two standard sizes of power unit which, in various combinations, meet the requirements of any individual installation. The electrical equipment is also more robust than before, and now includes inherent current limitation which protects the equipment in the event of a short circuit. The larger unit is fitted with a constant voltage transformer to provide a stable and effective performance under varying atmospheric and dust loading conditions. Cleaning is said to be very easy.

The Industrion range is completed by the oil mist precipitator, which has been specifically designed for the elimination of oil mist and smoke emanating from high-speed cutting, grinding and machining operations. *W. C. Holmes & Co. Ltd.*, Turnbridge, Huddersfield.

EMD 6776 for further information

WHAT'S NEW IN COMPONENTS

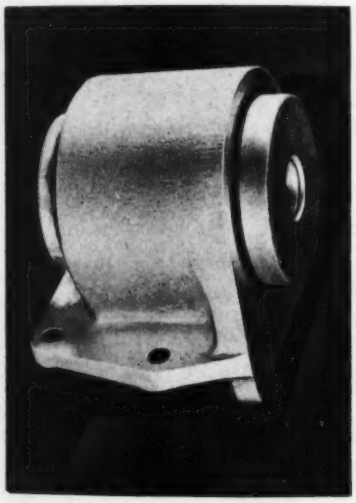
Tropicalised Equipments

Items protected against tropical conditions are now available from the Square D range of products. Devices currently obtainable in tropicalised form include starters, contactors, a.c. and d.c. relays, mechanically held relays and heavy-duty oil-tight control units. The degree of protection afforded on these tropicalised equipments is claimed to be more than sufficient to ensure satisfactory operation under the conditions detailed in BS 2011 (category H2). *Square D Ltd.*, Cheney Manor, Swindon, Wilts.

EMD 6777 for further information

Resilient Mounting

Although originally designed for resiliently mounting large-capacity tanks to the chassis of road vehicles, its simple four-bolt fitting makes the new Silentbloc mounting shown in the illustration a practicable proposition for other applications.



Vertical deflection is approximately $\frac{5}{16}$ in. at a maximum load of 5,000 lb. *Silentbloc Ltd.*, Manor Royal, Crawley, Sussex.

EMD 6778 for further information

Air Filter-regulator Unit

A new filter-regulator unit is announced for use with compressed air, combining efficient filtration and accurate pressure regulation in one compact economical unit. The unit is available in $\frac{1}{4}$ and $\frac{1}{8}$ in. pipe sizes.

Air first enters the filter section of the unit where a deflector causes a swirling motion in the air, the centrifugal action removing liquids and the heavier dirt particles. A "quiet zone" in the lower half of the filter bowl retains the separated liquids and prevents their return to the air line. Air then passes inwards through a filter element and then to the regulator part of the unit.

There is a choice of four grades of sintered bronze filter element, or alternatively a monel screen filter element. There is also a choice of a transparent plastics or metal bowl on the filter part of the unit. A balanced regulating valve, together with a baffle and syphon tube feature, is said to ensure that the regulator part of the unit provides an output with excellent flow and regulation characteristics. There is a choice of three regulating spring ranges, and both relieving and non-relieving types of unit are available.

The unit is suitable for input pressures up to 150 p.s.i. when fitted with the transparent, or 250 p.s.i. with the metal bowl. The respective inlet temperatures are 49 and 93 deg. C. *C. A. Norgren Ltd.*, Shipston-on-Stour, Warwickshire.

EMD 6779 for further information

Easily Cleaned Pump

Exclusive features of the Rotary Easy Clean Pump include splined shafts where rotors are fitted, and a standard type O ring joint between the rotor case and back plate. These pumps are suitable for suction lift, and can run on snore or completely dry for several minutes without damage. Manufacturers handling sticky and viscous fluids should be particularly interested in these units which are claimed to handle sensitive liquids without agitation and consequent impairment.

The pumps are manufactured in a range of five sizes for capacities from 50 to 10,000 gall./hr., for pressures up to 120 p.s.i. Glands are of the normal packed stuffing box type, but Flexibox or Crane

mechanical gland seals can be fitted if preferred. *Stainless Steel Pumps Ltd.*, Myrtle Road, Eastbourne, Sussex.

EMD 6780 for further information

Dust Filter

A new reverse flow dust filter is of the fabric sleeve type, and has an automatic cleaning device which operates continuously, ensuring that constant resistance to air flow is maintained. One of the main advantages of this method is that higher air speeds through the filter fabric can be used, which means that the overall dimensions of the plant are relatively small. *Harris Engineering Co. Ltd.*, York Works, Browning Street, London, S.E.17.

EMD 6781 for further information

High-temperature Thermometer

A new bi-metal high-temperature thermometer, specially designed for diesel engine exhaust gas and super-heated steam temperature indication, is now being produced. Before the introduction of the bi-metal instrument, only mercury-in-steel

thermometers could be used for measuring the higher temperatures of diesel exhausts. The thermometer is approximately one-third cheaper than its mercury-in-steel predecessor. It has a range of 100-650 deg. C., is free from oxidation up to 760 deg C., and can withstand temporary overloads. It comprises a self-compensating and shock-resisting multiple helix carried in a stainless-steel stem. Dial sizes are $2\frac{1}{2}$, 4 or 7 in. dia., giving a scale length of 5, $7\frac{1}{2}$ or 14 in. respectively. Vertical or horizontal mounting is available, and dials can be assembled at any angle. The head is pressure die-cast aluminium alloy, for strength with lightness, and a new flexible spring coupling eliminates gearing in vertical models. The general specification is the same as for standard heavy-duty industrial models. *British Rototherm Co. Ltd.*, Merton Abbey, London, S.W.19.

EMD 6782 for further information

Filter Lubricator and Regulator in One Unit

The Lub-Air-Ator combines a sintered bronze air filter, an oil supply in a glass bowl, and a pressure regulator which reduces line pressure to the actual machine or tool requirements and keeps it constantly at that pressure. Inlet pressures of up to 250 p.s.i. can be regulated, by a simple screw adjustment, to a range of 0-125 p.s.i.g.

The filter is also enclosed in a glass bowl, and a whirling action baffle plate throws the foreign matter to the sides of the bowl so that it then sinks to the bottom. Cleaning is said to be simple, as the accumulation of dirt can be blown out by opening the drain cock. *A. Schrader's Son*, 829 Tyburn Road, Birmingham, 29.

EMD 6783 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on *each* card.

EMD 6670 for further information

What's exciting about these homely articles?

Simply this. In each one of these famous products with famous names, a simple piece of metal tubing enabled their function to be performed more economically and effectively. A simple piece of metal tubing . . . *but the right tubing.* Ellay small diameter non-ferrous tubing precision made for the part. This brand of tubing can do a lot for you as well . . .

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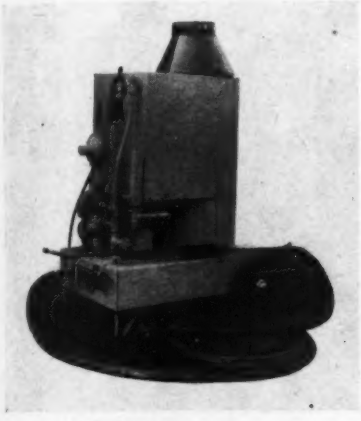
WHAT'S NEW IN EQUIPMENT

Portable Steam Cleaner

The BMD McCoy steam cleaner develops from 80 to 100 lb. pressure at the nozzle in 1¼ min. from a cold start, and maintains this for constant use at the rate of approximately 120 gall./hr. It operates efficiently on natural, manufactured, propane or butane gas, and is of heavy-gauge steel all-welded construction. The heater coils are air insulated, and all



working parts are visible.

The large ¾-in.-dia. coils help to eliminate scaling problems. *Magnus Chemical Co. Ltd.*, Salisbury Road Industrial Estate, Uxbridge, Middlesex.

EMD 6784 for further information

Three-point Pipe Bender

A new 1½-in. capacity hydraulic three-point bending machine has been introduced into the Staffa range of pipe bar and section benders. This unit, which has been designated the B2 and which does not require a bench or stand, consists of a powerful hydraulic pump ram unit, a forming head assembly and centre formers for ½-1½ in. nominal bore pipes to BS 1387.

The whole assembly complete in a wooden case weighs only 110 lb., and particular features of the machine are the angle of bend indication marks cast in one end of the formers. The hydraulic unit permits easy and "one-hand" operation. Very little maintenance is required, and when an overhaul is due the various seals and washers are easily removed. A full 90° bend can be made in 1½ in. pipe in 60 sec. *Chamberlain Industries Ltd.*, Staffa Works, Argall Avenue, Leyton, London, E.10.

EMD 6785 for further information

Industrial Direct-writing Recorders

A new range of industrial direct-writing recorders, manufactured by Officine Galileo, of Florence, is now available in the U.K. These instruments enable the study of phenomena of any nature to be performed with a single recorder, by making a suitable selection of interchangeable pre-amplifier units.

The recorders, employing ink pen or hot stylus, can be supplied in several standard models—portable single-pen, two- or four-pen instruments, or rack-mounted on wheels and having two, four, six, eight, sixteen or thirty-two channels, thus permitting the simultaneous recording of an equivalent number of phenomena.

The pre-amplifier units, containing voltage amplifying stages, their controls and (if required) filters, incorporate printed circuits and transistors. They are sturdy and compact and may be inserted and removed quickly from the recording unit. A wide range is available.

The hot stylus record has the advantage of being in cartesian co-ordinates, permitting easy interpretation and correlation of multi-channel recording. For low-speed phenomena this system affords high resolution and a well-defined trace. The multi-channel instruments may have a built-in photographic recorder allowing the examination of phenomena whose higher frequency components (200-800 c/s) would not be reproduced by direct-writing pens.

The Galileo recorders operate from a power supply of 110 to 220 V., 50 c/s, and have a response time of 0·01 sec. and paper speeds varying from 2·5-100 mm./sec. If required, other paper speeds and a time-marker may be obtained. *Leland Instruments Ltd.*, 145 Grosvenor Road, Westminster, London, S.W.1.

EMD 6786 for further information

Power Presses

The new range of Bentley friction clutch power presses comprises three non-inclinable presses of 60, 100 and 200 tons respectively. The 6-h.p. 60-ton press gives 50 strokes per min., has a fixed stroke up to 6 in. max., and 18 in. daylight on top dead centre with 3 in. ram adjustment up. Its table surface is 20 in. wide by 24 in. with 12½-in.-dia. bed aperture.

The 10-h.p. 100-ton press gives 40 strokes per min., has fixed stroke up to 8 in. max., and 22 in. daylight on top dead centre with 4 in. ram adjustment up. Its table surface is 26 in. wide by 32 in. with 15½ in. dia. bed aperture.

The press frame is fabricated from steel plates, and so designed that no weld is in tension or shear. Ram and con rod are of cast steel, and the shafts of nickel chrome steel. The four lengthy guideways, being at the corners of the ram, allow intricate tools and dies to be accommodated.

Control of ram movement may be either hand- or foot-operated, a selector switch giving alternative control of clutch only (with isolated motor) and inch, for tool-setting; or operated by single, repeat or continuous strokes. Standard equipment includes top extractor; ratchet adjustment to ball screw; pneumatic equipment including oil mist lubricator; and lubrication system. *Samuel Griffiths (Willenhall) Ltd.*, John Harper Street, Willenhall, Staffs.

EMD 6787 for further information

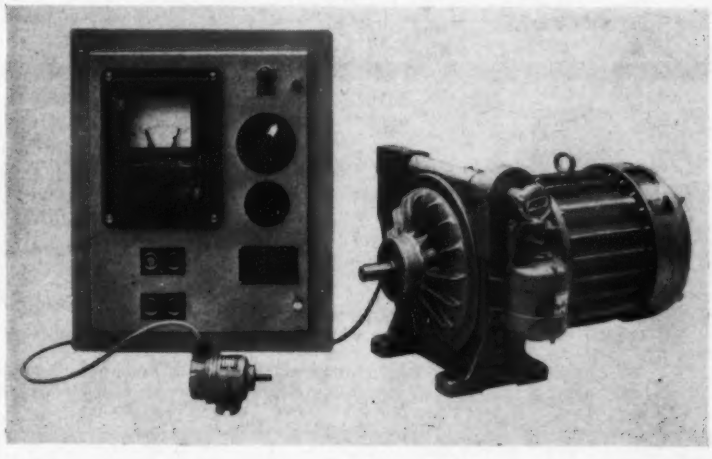
Automatic Speed Control

An electronic speed corrector unit which can be used in conjunction with any standard Kopp electrical remote-control unit is designed for the control of constant speed or feed mechanisms, or for speed governing, for example, of winding machines in the textile, paper and wire industries, and also of conveyors. Constant speed is achieved by maintaining a constant voltage signal through a generator driven by the material concerned. Should this signal change, then it is transcribed by the Automatic Speed Control to correct the resultant speed modulations.

The particular speed selection is entirely dependent on the material or process. Each speed requirement is set by dial control.

Each selected speed is held constant within ±5 per cent maximum and ±0·5 per cent minimum, dependent on the chosen generator speeds. The unit is totally enclosed in a cabinet suitable for panel or wall mounting. All external wiring is to terminal blocks inside the control panel. *Allspeeds Ltd.*, Royal Works, Clayton-le-Moors, P.O. Box 43, Accrington, Lancs.

EMD 6788 for further information

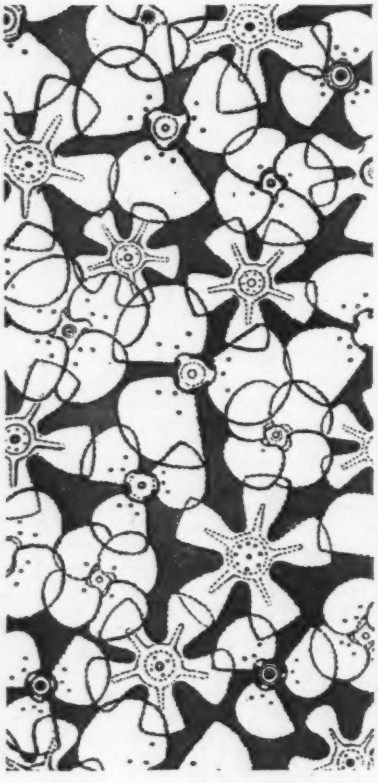


EMD 6671 for further information

PROPELLER FANS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY

AIROTORS?
YES, SIR!
BIGGEST RANGE
IN THE COUNTRY

BOFFINS?
YES, SIR!
BIGGEST BRAINS
IN THE COUNTRY



The world-famous TORRINGTON air-impellers are now made and sold by SMITHS.
SMITHS offer the widest range of airotors and propeller fans in this country, and can assemble and deliver promptly from a wide range of tooled stock components.
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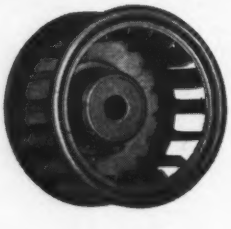
PROPELLER FANS
From 3″ to 24″ diameter, either rotation, in a variety of pitches. Light, rigid, quiet, efficient.



AIROTORS
From 1½″ to 11″ diameter, available in steel or aluminium. In widths from ⅝″ to 11″.

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S. SMITH & SONS (ENGLAND) LIMITED, AIR IMPELLER DEPARTMENT, WITNEY, OXON. TELEPHONE: WITNEY 678

WHAT'S NEW IN THE OFFICE

"Floating" Fluorescent Lamp

The Dazor fluorescent universal model "floating" lamp is designed for use with two 15-watt tubes. Type 2124 has a 24 in. arm extension and type 2134 a 34 in. extension. The lamp is suitable for use on a.c., 200-250 V., 50 c/s.

The base may be clamped or screwed to any surface—horizontal, vertical or sloping. The finish is statuary-bronze

baked enamel over bonderising. Optional colours at no extra charge are grey, frost-green or frost-tan. *M. R. Aust*, 26 Haldon Road, West Hill, London, S.W.18.

EMD 6789 for further information

Bench-mounted Drawing Stand with Front Controls

The redesigned Admel Springbrook drawing stand is claimed to be the first bench-mounted stand to have front controls enabling both height and angle adjustment to be made from a sitting position. From the draughtsman's point of view, the ease of operation afforded by front control puts an end to the minor irritations and distractions that have been previously associated with bench-type equipment.

As the name implies, the Springbrook is a spring counterbalanced stand. The whole weight of the drawing board and ancillary equipment is held in suspension by means of a horizontally tensioned spring and cable—this allows the board to be adjusted for both height and angle without any manual effort. The actuating mechanism is totally enclosed, giving the Springbrook a compact and streamlined appearance. It is easily mounted on a bench, reference table or even a plan cabinet, as the board adjustment allows for plenty of knee room. *Lawes Rabjohns Ltd.*, Abbey House, Victoria Street, London, S.W.1.

EMD 6790 for further information

Drawing Pen

The Fedragraph technical drawing pen now incorporates new features which are an improvement over existing models. There is a clear perspex window to allow the user to note the level of the ink in the pen, and the point can be taken out of the pen, even while the pen is full of ink, and a point of a different gauge inserted. A handy plastic container of five other grades of points is also available. Repairs can be carried out easily, since

cleaning liquid (water or instrument cleaner) enters all the interior parts of the pen after removal of the writing insert. *Lawtons of Liverpool Ltd.*, 60 Vauxhall Road, Liverpool, 3.

EMD 6791 for further information

Storage Cabinet for Large Drawings

A 44 in. high sheet-metal cabinet holding thirty, 1 in. shallow trays is specially designed to store the large antiquarian drawing "in the flat". These steel trays, each of which is capable of filing 50 drawings, have radiused handles and slide freely on non-mechanical runners. The base of the trays is swaged to give additional strength, and the rearmost portion is cased-in "envelope-pattern" to protect the contents and prevent loss of drawings down the back of the cabinet. Finger holes have been punched in the base of the front corners of each tray to facilitate the handling of drawings. Speedy location is ensured by reference slip holders on the front of the trays.

Attractively finished in duo-grey, this new metal cabinet takes up a floor space of 55 × 35¾ in. *James H. Randall & Son Ltd.*, Paddington Green Works, W.2.

EMD 6792 for further information

New Publications and Technical Literature

Lodge Plugs Ltd.: 36-page brochure of technical information and data on Sintox, a high-alumina ceramic material manufactured by this company. An abbreviated 8-page version is also available. Rugby.

EMD 6793

Enfield Rolling Mills Ltd.: 17-page brochure on copper-alloy ERM resistance welding electrode materials. Brimsdown, Enfield, Middlesex.

EMD 6794

Alcan Industries Ltd.: Leaflet dealing with the Noral Treadplate, which is an aluminium flooring material having a pattern of raised lozenges, designed to provide a safe foothold under all conditions of use in factories, goods vehicles and ships. Banbury, Oxfordshire.

EMD 6795

Low Moor Fine Steels Ltd.: 50-page catalogue illustrating the wide variety of applications of extruded steel sections, produced by the company to customers' specifications. This catalogue is published for the special benefit of design and development engineers, and features reproductions of actual blueprints. Low Moor, Bradford.

EMD 6796

Shell Chemical Co. Ltd.: Folder containing technical bulletins describing the ten grades of Carlona low-density polyethylene at present available. 170 Piccadilly, London, W.1.

EMD 6797

Moore & Wright (Sheffield) Ltd.: Two editions of the firm's catalogue of precision and hand tools—one edition large and of good quality, the other a pocket version containing the same information. Handsworth Road, Sheffield, 13.

EMD 6798

Croda Ltd.: 8-page loose-leaf brochure, listing the anti-corrosive and other protective materials manufactured by the company to Government and other official specifications. Cowick Hall, Snaith, Goole, Yorks.

EMD 6799

Turner Brothers Asbestos Co. Ltd.: "Asbestos in the Electrical Industry" is a 32-page well-illustrated publication dealing with the range of Turners asbestos products available, and illustrating the many and varied ways in which the electrical field is served by asbestos textiles. P.O. Box 40, Rochdale, Lancs.

EMD 6800

John Harper & Co. Ltd.: Leaflet describing the properties, design data and applications of Harper s.g. iron. Albion Works, Willenhall, Staffs.

EMD 6801

Shell Chemical Co. Ltd.: Folder containing four technical leaflets on Carlona P polypropylene (types Nos. DE61, FE61, HM61 and KM61). 170 Piccadilly, London, W.1.

EMD 6802

Imperial Chemical Industries Ltd.: "Fluon Polytetrafluoroethylene", a 36-page brochure describing the processing of Fluon granular polymers. Plastics Division, Welwyn Garden City, Herts.

EMD 6803

BX Plastics Ltd.: "Developments in Plastics", a 20-page illustrated brochure on thermoplastic materials and their applications. Publicity Department, Highham Station Avenue, London, E.4.

EMD 6804

Mobil Oil Co. Ltd.: 10-page technical bulletin describing the free-piston engine, which consists principally of a gasifier and a turbine. Caxton House, Westminster, London, S.W.1.

EMD 6805

New Holden advance with

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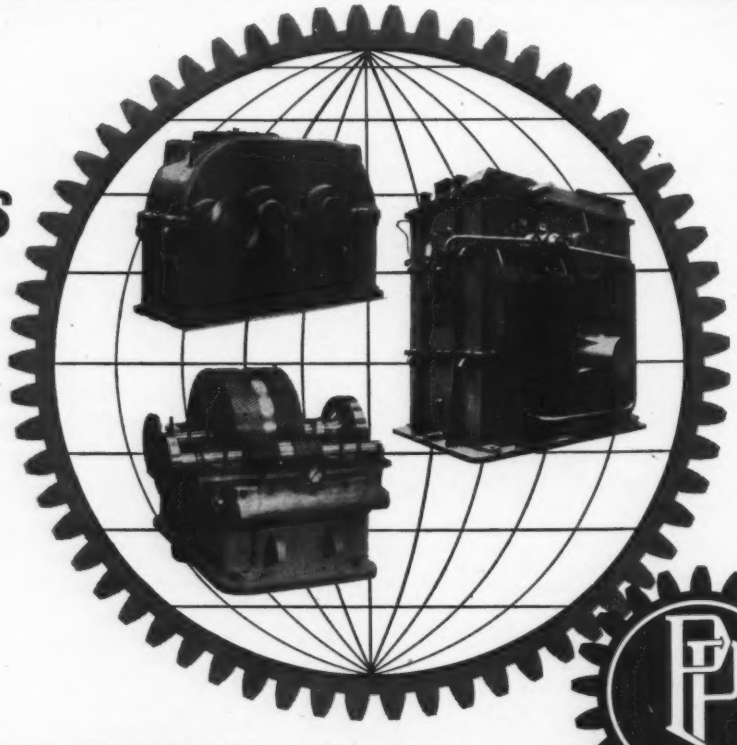

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News of Industry

The Staffa hydraulic, five-cylinder, low-speed, high-torque reversible radial piston motor produced by **Chamberlain Industries Ltd.** provides the driving torque for the drums of the new **Winget** Challenge truck concrete-mixers. The motor is rigidly mounted to the mixer frame, and a nickel alloy steel pinion splined on to the motor shaft engages with a manganese steel gear ring bolted to the drum base. The hydraulic circuit consists of a closed system with only a small amount of oil in circulation, and the axial piston-type pump powered from a drive taken from the end of the vehicle engine crankshaft provides infinitely variable delivery in both directions at constant speed with a unidirectional sense of rotation. One control lever operates the pump to meet all functions of charging, agitating, mixing and discharging the mixer drum; this lever is controlled by hydraulic actuators, eliminating the need for cables, rods, etc. One unit is located in the vehicle cab, and a duplicate unit is positioned at the rear of the machine.

A mixometer indicates the correct drum speed for charging, mixing and agitating, and by controlling the revolutions of the drum, delivery of uniform concrete is always ensured. This device also records a running total of all drum revolutions between charging and mixing, while a trip mechanism can be reset for each journey.

A low-capacity lorry-mounted crane now being manufactured by **Cohen Brothers (Electrical) Ltd.**, of Manchester, has been designed by the company to meet their own special requirements in connection with the erection of street lighting columns. Because of its great manœuvrability, low operating costs and very simple maintenance, the crane should find applications in almost every industry—it is claimed to be the lowest priced crane of its type in the world. Known as the Kwiklift, it is capable of lifting 2½ tons to heights of over 20 ft., and basically comprises a hydraulically operated crane unit mounted on either a Morris or a Bedford chassis. The jib of the crane is constructed in angle sections and has three permanently fixed swivel hooks, one of which will lift 1 ton to a height of 21 ft. 7 in.; the second hook will lift 2 tons to a height of 19 ft. 8 in., and the third will lift 2½ tons to 17 ft. 9 in. At the lowest position of the jib the hooks are at about 5 ft. above ground level. The jib is operated by a single hydraulic ram which is controlled by the operator from inside the cab of the lorry.

A new type of heat transfer equipment design is claimed to reduce the heating time of metals by 85 per cent. The new system, introduced by the **General Electric Co.** in the U.S.A., is called a "fluidised bed", and it heats parts in a dense dispersion of hot, highly turbulent solid particles suspended in a controlled stream of air or other gases. These particles have similar physical properties to a liquid, but are inert and do not wet the work. The fluidised bed process can be used in annealing, normalising, solutionising, ageing, hardening and isothermal transforming, and is mostly used for metals, although the kiln drying of wood and other applications are under investigation.

Heating beds are available up to 930 deg. C., and a typical batch-type system might consist of an electrically heated hot bed, a metal-lined quench bed having a water-cooled heat exchanger, a job crane and a power control centre. There are no toxic fumes, and no post-cleaning of work is required. A wide variety of both standard and special work handling equipment can be used with the equipment, parts being processed individually or in batches. Trays, baskets or fixtures are available, and fluidised bed equipment can be designed for use with cranes, elevators or other loading equipment.

MEETINGS AND EXHIBITIONS

Industrial & Trade Fairs Ltd. (jointly owned by George Newnes Ltd. and The Financial Times Ltd.) have acquired, with Beck & Pollitzer Ltd., the business of F. W. Bridges & Sons Ltd., exhibition organisers. A new company has been formed—**Bridges Exhibitions Ltd.**

The **Thirteenth British Electrical Power Convention** is to be held at Eastbourne from June 12 to 15, and the theme is to be "Electricity in the Prosperity and Welfare of the Nation". Lectures will include "The British Electricity Transmission System", by Sir Christopher Hinton; "Some Aspects of Efficiency and Economy in Distribution", by the chairman of the Southern Electricity Board; "British Electrical Manufacture in the National Economy"; and a lecture by the chairman of the British Columbia Electrical Co. Ltd., of Vancouver.

The second national **Laboratory Apparatus and Materials Exhibition** will be held in the Royal Horticultural Society's New Hall from June 19 to 22. Every possible type of laboratory requirement will be shown and demonstrated.

An international conference on **Heating, Ventilating and Air Conditioning**, with an associated exhibition, is to be held at Olympia from September 27 to October 4. The conference will cover three main themes: "Administrative Advances Likely in the Next Ten Years"; "Technical Advances Likely in the Next Ten Years"; and "Integrated Design of Architectural and Engineering Services for Economy of Building Construction". A programme of technical visits is also being arranged.

The **Institution of Engineering Inspection** and the **Society of Non-destructive Examination** are holding a National Conference at Oxford from September 5 to 8, to discuss the function of management in relation to inspection, the economics of inspection and non-destructive testing, and the recruitment, education and training of inspection staffs. Residential accommodation at Queens' College and New College has been reserved at £9 10s. per delegate; this sum includes all meals and the conference fee.

FILMS

An Industrial Notebook on Iron and Steel is the second film in the **Shell-Mex & B.P. Ltd.'s** Industrial Notebook series, and is a miscellany of items about the iron and steel industry, together with some interesting applications, both old and new. It is available in black and white in 35 and 16 mm. (duration 27 min. 48 sec.) from the Shell-Mex & B.P. Film Library, Shell-Mex House, Strand, London, W.C.2.

R. H. Cole & Co. Ltd., 2 Caxton Street, Westminster, London, S.W.1, now have available a 16-mm. film in colour, with English sound track, devoted to the processing and end applications of Makrolon, the new polycarbonate thermoplastic.

The **United Kingdom Energy Authority** are now offering two new films on free loan. The first, *Dounreay Symposium* (Eastman colour, running time 27 min.), covers the highlights of the construction and commissioning of the fast reactor experiment at Dounreay. The second film, *Steel for Nuclear Power* (Eastman colour, running time 18 min.), is mainly concerned with steels for reactor pressure vessels. Copies of the films, in 35 or 16 mm., may be obtained from 11 Charles II Street, London, S.W.1.

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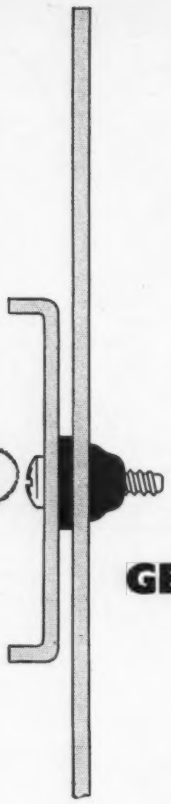

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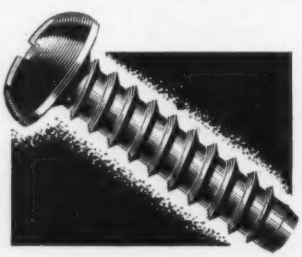

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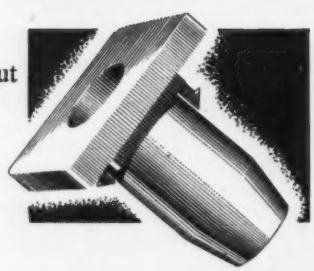

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